THE EAST AFRICAN AGRICULTURAL JOURNAL

of

KENYA
TANGANYIKA
UGANDA AND
ZANZIBAR

Vol. XVII—No. 1

JULY
1951

IN THIS ISSUE:

Price
2/50

THE

EAST AFRICAN AGRICULTURAL JOURNAL

VOL. XVII—No. 1 JULY, 1951

Printed and published by the Government Printer, Nairobi.

Issued under the Authority of the East Africa High Commission and published every three months—July, October, January, April. Volume consists of four issues (commencing July issue).

EDITOR: D. W. DUTHIE,

E.A.A.F.R.O., P.O. BOX 21, KIKUYU, KENYA

Subscription Sh. 10 per volume including postage, payable to the Editor. Subscribers are advised to remit postal orders in payment, otherwise bank commission must be added in the case of cheques.

The Editor does not hold himself responsible for opinions expressed by contributors.

Matter submitted for publication should preferably be sent through the local member of the Editorial Board. Double spacing should be used in typescript. Contributors receive 25 prints of their articles free. Additional copies may be obtained on payment if asked for in advance. Prints bear the same page numbers as the original articles in the Journal, except where, to meet a contributor's wishes, prints are supplied before publication has been completed.

Readers are reminded that all agricultural inquiries, whether they relate to articles in the Journal or not, should be addressed to the local Director of Agriculture, and not to the Editor.

CONTENTS

INDEX TO ADVERTISERS

COMMONWEALTH AGRICULTURAL BUREAUX

This organization formed by the Governments of the British Commonwealth provides up-to-date information in the form of abstracting and reviewing journals, technical communications and bibliographies on all aspects of science and practice as applied to agriculture, horticulture and forestry.

JOURNALS

The following list comprises journals and other periodical publications. Subscription rates are quoted after each; in certain cases (journal marked with an asterisk) a 20 per cent deduction is made for subscribers in the British Commonwealth who send their subscriptions direct and not through a bookseller.

	Sh.		*Sh.*
Bulletin of Entomological Research ..	40	*Plant Breeding Abstracts	35
Review of Applied Entomology (Series A)	40	*Herbage Abstracts	35
		*Field Crop Abstracts	35
Review of Applied Entomology (Series B)	20	*Animal Breeding Abstracts	35
		Helminthological Abstracts	35
Review of Applied Mycology ..	40	*Dairy Science Abstracts	35
*Soils and Fertilizers	35	*Forestry Abstracts	New rate undecided
Veterinary Bulletin	40	Forest Products and Utilization ..	10
Index Veterinarius	100	*Horticultural Abstracts	35
Nutrition Abstracts and Reviews ..	60		

COMMONWEALTH BUREAU OF PASTURES AND FIELD CROPS, ABERYSTWYTH

Bulletin 39.—*Five Hundred Varieties of Herbage and Fodder Crops. Price Sh.* 15, *March*, 1948.

This work brings together in the first place information received from specialists in many parts of the world on crop varieties used in the feeding of farm stock. The notes have been made to give, in as concise a form a possible, the necessary details regarding origin, adaptation, characteristics, and use of the strains in various countries, together with possibilities of obtaining supplies. Secondly, the index has been designed to supplement the first part and contains references to published information on crop varieties compiled over a period of 17 years in the Commonwealth Bureau located at Aberystwyth.

The information, which is collated in this way for the first time, will reveal not only the need for a completion of the data by the inclusion of entries from other countries, but also the desirability of some attempt being made by research workers to achieve uniformity in regard to standards, nomenclature, synonyms, etc.

COMMONWEALTH BUREAU OF HORTICULTURE AND PLANTATION CROPS, EAST MALLING

Technical Communication No. 17.—*Chemical Composition of Plants as an Index to their Nutritional Status, by D. W. Goodall and F. G. Gregory. A Review of* 165 *pages with* 900 *references to literature. July*, 1947. *Price Sh.* 9.

Optimum nutrition is of paramount importance to plant yield. Yet the determination of the nutritional requirements of any plant is one of the hardest problems of agriculture and horticulture.

Does its solution lie in soil analysis, plant analysis, injection methods or a combination of these and other methods? The authors of T.C. 17 sift and discuss the enormous written evidence on different methods and technique and thereby do much to clear the ground for future work in this field.

All inquiries regarding these publications should go to:—

COMMONWEALTH AGRICULTURAL BUREAUX, Central Sales Branch, Penglais, Aberystwyth, Great Britain.

THE RED-BILLED OXPECKER AND ITS RELATION TO STOCK IN KENYA

By Vernon D. van Someren, Game Dept., Kenya, Formerly Veterinary Research Institute, Kenya

(Received for publication on 2nd March, 1951)

The close association between the Red-billed Oxpecker (*Buphagus erythrorhynchus erythrorhynchus* (Stanley)) and the larger herbivorous animals in East, Central and South Africa has been known for many years. Their habit of perching and feeding upon game animals such as rhinoceros and buffalo, and giving warning to the beasts when danger approaches by their hissing alarm call, has earned for them a bad reputation among professional hunters.

With the introduction and gradual extension of cattle farming among both Europeans and Africans in these countries, these birds have found cattle a very suitable host upon which to feed; and their predilection for opening up and attacking sores and abrasions on stock animals has also earned for them among stock-owners a worse reputation.

Jackson (1938) records them as being a great curse to pack donkeys and mules with sore backs in the early days, since many animals on *safari* died entirely through the attentions of these birds. Although this habit of feeding upon open sores had been known for many years, it was not until 1933 that a scientific study of their food and feeding habits was made by R. E. Moreau (1933), who tried also to assess their status as pests or not.

Moreau examined the stomach contents of 58 Red-billed Oxpeckers, and summarized the field evidence on their food and feeding habits, mainly in Tanganyika. He found that ticks and other blood-sucking parasites formed an important and probably major part of the birds' diet. A total of 2,291 ticks of all sizes and stages of development were found in 55 of the birds examined, the average being just over 41 ticks to each bird. 95 per cent of these ticks were found to be potential vectors of tick-borne diseases in East Africa, such as east coast fever and heartwater. *Diptera*, probably all blood-sucking species, were eaten by 44 of the birds, two stomachs containing *Diptera* exclusively. Other organisms, among which lice were the most numerous, formed an insignificant portion of the food, while animal hair occurred in the majority of stomachs, but in varying quantities. Most of the blood clots found in the stomachs were found to be derived from engorged ticks which had been swallowed whole. It was suggested that these clots had not been ingested directly by the bird from open sores, and only one instance was recorded of an Oxpecker obtaining food in any other way than from a living animal—this being a record of a bird feeding upon some impala meat hung out to dry.

Moreau found little satisfactory field evidence that the Oxpecker itself starts an excavation in the hide of an animal for the purpose of feeding, but that the birds undoubtedly avail themselves of any opportunities presented by existing sores or abrasions caused otherwise. On balance he concluded that when stock animals can be looked after and abrasions protected, the birds are not a nuisance, but may do more good than harm.

Recently, however, with the extension of dipping practices to kill cattle ticks in most of the European stock areas in Kenya, it has been suggested that the birds were causing more damage to stock than formerly because their natural food of ticks was becoming scarcer; and that they were turning more and more to making deliberate incisions in order to feed on flesh or blood. It was considered therefore that control measures should be greatly enforced.

Before considering ways of control, however, it was felt that it was necessary to obtain more accurate evidence of the status of these birds in the highland stock-rearing areas of Kenya, and to find out whether the presumption that sore feeding had become more prevalent was in fact true. Questionnaires were therefore sent out to all District Veterinary Officers in European areas, for distribution to local farmers to fill in and return. When the investigation had to be closed three months later (August, 1947) 55 completed forms had been returned out of 400 distributed. This is unfortunately not a high percentage, but for some reason all such questionnaires and and inquiries are poorly responded to in this Colony. In this particular case, a natural suspicion on the part of stockowners of any question dealing with dipping may have contributed to this small return. In addition, of course, many stockowners do not pay much attention to these birds.

Fortunately, however, the distribution in space of these completed forms has covered the main stock areas of Kenya fairly well, except for the Trans-Nzoia and Uasin Gishu districts. (*See* map.)

Inquiry into Present Status

The questions asked were designed to establish the status of the birds in relation to residence or any local movements; their status in relation to any decrease or increase in numbers since dipping was started; and correlated with this last, whether damage done by the birds had increased or decreased since dipping. Personal observations as to whether the birds started the sores themselves were sought, together with opinions as to their harmfulness or otherwise, and any notes of interest on habits, nesting, roosting, control, etc. Most of the returns received gave very full and interested answers, and analyses of the replies are given below.

Locality and Altitude.

Returns were divided into the areas shown on the map, which correspond roughly to the main geographical districts of Kenya Colony. Within these areas the number of returns was distributed as follows: Coast area, 1; Nairobi and plains area, 10; Mount Kenya area, 7; Aberdare area, 17; Rift Valley area, 9; Nyanza area, 8; Uasin-Nzoia area, 3. The localities of each of these returns are indicated on the map. Apart from one negative return of no birds seen at sea-level (Dar es Salaam), localities from which returns were sent varied in altitude from 4,600 ft. to 8,500 ft. It is probable that Oxpeckers occur at all altitudes up to at least 9,000 ft. where suitable animal hosts are found. Whether or not they are absent from sea-level is not known.

Type of Country.

Oxpeckers were recorded in all the four types of country mentioned in the questionnaires, the returns being distributed as follows: Plains, 35; Scrub, 22; Thorn bush, 21; Forest, 22. There is no doubt that these birds occur more frequently in the open types of country than in forest such as rain forest, or the dry forest on the south-west slopes of Mount Kenya for example. In such forest areas they are absent except in the fringes where game and cattle graze; probably all the returns for "forest" country refer to such open forest fringes. They also are found in open cultivated country such as maize fields or in coffee crops if cattle graze therein.

Resident Status.

Thirty-seven of the returns state that the birds are resident in the area all the year round, three were doubtful (Thomson's Falls, 2; Mweiga, 1), six that they are not resident all the year (Ol Joro Orok, Njoro, Songhor, Sotik 2; Upper Kiambu); being seen only infrequently (Ol Joro Orok); present in the dry season only (Kikuyu); "used to be" (Ngong, Machakos, Songhor); "more at certain times" (South Kinangop); and not present in the cold weather of July and August (Upper Kiambu).

It appears probable from the returns that the birds may not be resident all the year above an altitude of about 7,000 ft. in some areas, though in other areas they appear to be year-residents at this height. Elsewhere, apart from the decreases mentioned below, they would appear to be a fully resident species, subject only to slight local movements within small areas.

Numerical Status in Relation to Stock-dipping.

In localities where cattle dipping is not practised, three returns report the numbers of birds as being static, four report an increase within the last few years and one reports a decrease. In areas where cattle dipping is carried out regularly, 27 returns state that there had been a marked decrease in numbers since dipping was started, 13 report that the numbers were static while two report an increase.

Although it should be pointed out that these returns are all based on visual estimations only and not on actual counts, many returns were quite emphatic that there had been either a partial or complete disappearance of birds since dipping was started, although apparently in a few other areas dipping had had little effect. Unfortunately it is not practicable to ascertain the proximity of undipped areas to most of the localities, or the area surrounding each locality which is kept tick-free by dipping on adjacent farms; and these factors would be of some importance in the disappearance or otherwise of the birds from a certain locality. Furthermore it is probable that any decrease reported in one locality is relative only, the birds having moved elsewhere. These results hold good from over all the areas from which returns were sent.

A few selected individual comments are given below. In the Naivasha area one observer states that large numbers were present in 1943, the birds probably increasing on the farm owing to the scarcity of game, but since the

departure of the Italian prisoners of war, who used to kill the game, the latter has returned to a large extent and the birds decreased on the cattle again. In the Thomson's Falls area, heavy attacks were made by the birds on a sick beast which had not been dipped for two weeks, though the birds otherwise were scanty in this locality. Another return from this same area reports them as being seen on undipped work oxen only.

At Ol Kalou, tick birds began to attack cattle which had not been dipped for four months, though none were seen previously on dipped stock. At Ol Joro Orok, nearby, birds were seen only on an ox which had a sore, being scanty otherwise. At Ngong, the birds have vanished entirely from one farm since all the stock was regularly dipped, and this statement is typical of many other returns (South Kinangop, Laikipia, Machakos, Gilgil, Songhor, Sotik).

At Mweiga on one farm where undipped donkeys were kept, the birds were numerous on these animals. When the donkeys were disposed of, the birds disappeared and did not transfer their attentions to the dipped cattle. It is reported from Songhor that the birds have moved away from dipped areas to the surrounding "dirty" areas of Fort Ternan, Nyanza and the Nandi district.

The above remarks are characteristic of the relationship between Oxpeckers and dipping. Moreau (loc. cit.) stated that is not surprising that Oxpeckers should disappear in districts where dipping is extensively practised, and this inquiry has largely confirmed this statement. The late Dr. Austin Roberts has also informed me (*in litt,* 1947) that in South Africa the bird is now quite a rarity outside the Kruger National Park, preserved for game animals; this he presumed being due to the prevalence of dipping everywhere in the Union outside the Game Reserves.

Stock Damage by Oxpeckers.

An important fact for the livestock industry emerges from the inquiry, and that is that there has been no general increase in the damage done by the birds since dipping has been in use. Although two returns reported an increase in damage (one on horses only, presumably undipped), 35 report no increase in damage in dipped areas.

In undipped areas, two report no increase in damage, and none report an increase. It seems clear therefore that the birds have not taken to an alternative diet of blood from sores only since their natural food of ticks has been destroyed in dipped areas, but instead have disappeared from such areas.

Occurrence on Various Livestock.

Where the birds do occur, 40 returns report them as frequenting cattle most, 21 on horses, five on sheep, four on pigs and two on goats. In nearly all herds of mixed livestock, they are reported as commonest on undipped stock, especially horses; dipped animals appear unattractive or even repellent. One farmer reported having found dead birds in his paddock after the stock had been dipped, apparently a somewhat unusually infrequent occurrence as no other returns mention this; one might have supposed that arsenic-poisoned ticks would have been more poisonous to the birds.

Other returns report the birds as occurring on rhino, buffalo and eland, but not on waterbuck, Grant's gazelle or impala and zebra (Nanyuki, Mweiga). In the Ngobit-Suguroi area, however, the absence of zebra during the last few years has been held responsible for the absence of the birds, by one observer.

Opinions concerning harmfulness or otherwise.

Where damage is done by the birds to livestock, 28 of the returns consider that the birds themselves actually break the skin and start sores in order to feed on the blood or exudate. Fifteen returns state that they do not, but enlarge existing sores. The remainder are doubtful.

One observer (Kikuyu) considers that they attack only aged stock or young calves, and not agile animals, and another (Kinangop) reports them as attacking the noses of newborn calves, and also the area at the base of the neck where the hair turns forward. Whenever ticks are picked off a beast, a small bleeding spot is usually left, and several observers state that the birds will attack such raw spots and enlarge them.

According to other farmers, the birds are more inclined to attack and start sores on old cattle or those in poor condition, and ungroomed horses are a favourite host. They are reported as frequenting animals which are known to be tick-free, but nevertheless have open sores on their bodies, and this can be confirmed from personal observation. Undoubted evidence of a tick-bird causing a wound in an area of previously unbroken skin,

free of ticks, at the base of a bull's tail has been reported by a careful observer at Machakos.

It is interesting to note African opinion on the matter; among the Nandi, who are a cattle-rearing tribe, it is stated quite definitely that the tick birds do not start sores on the cattle, and it is the custom of some members of this tribe to encourage the birds by feeding them on milk (it is not stated how!), and the birds are always welcome and never killed. The Akikuyu in Embu district consider them beneficial, but the Lumbwa, another cattle-rearing tribe, consider them harmful as they spread disease. This latter point is mentioned by quite a number of the returns, as being held against the birds, and it is of course possible that the birds may transmit mechanically such diseases as rinderpest, anthrax or nagana; but as Moreau (loc. cit.) points out, these diseases may also be carried by blood-sucking flies, which the birds will eat, and it is doubtful whether the birds are an important factor in disease transmission.

From the above remarks, there seems therefore no doubt that the birds can make an incision in a tender-skinned area of a beast, as I have confirmed myself, but probably in the majority of cases they merely enlarge an existing abrasion.

In spite of this tendency to attack stock, 27 of the returns consider that the birds are beneficial, 22 that they are harmful, the remainder being doubtful. Their usefulness lies in their tick-destroying habits; but it is also clear from several of the returns that the birds are unable to keep an animal completely free of ticks. Many people do not mind them in small numbers only, but consider them a nuisance if in quantity.

From the behaviour aspect, there is little field evidence that they annoy stock by their attentions, as do biting flies, and nearly all animals seem indifferent to their presence except when they concentrate on areas round the eyes and ears. As Moreau has also observed, it is remarkable how insensitive stock seem to be, even when the birds nibble at an open sore, and this I have confirmed many times myself.

A further remarkable feature is how seldom sores, which are kept open by tick birds, seem to suppurate—the wound is always clean, and probably any septic matter is removed by the birds. When the birds are kept off such wounds, they heal readily. An interesting point is that game animal hides apparently do not show any tick-bird damage.

General Biological Observations

Food of Buphagus e. erythrorhynchus.

A request for birds for stomach examinations met with a poor response, and I have been able to examine only 12; as will be seen from Table I, however, the results have fully confirmed Moreau's original observations.

The main bulk of their food is ticks, with flies such as *Musca* or *Stomoxys* a close second. Lice and mites are also eaten in small quantities, and the birds have also been observed eating such non-parasitic insects as the flying stages of termites. It is interesting to note that flies and such mobile insects are not taken when settled on the beast, but are snapped up on the wing, the Oxpecker usually flying off the animal on which it is settled and taking the flies in the air in a flycatcher manner, returning again to settle on the animal. Hair in greater or less quantities, seems to be an invariable item present in the stomachs. Whether this is taken purposefully or not is not known, although it would appear to have little nutritive value. It is probable also that such hair is cast up again in the form of pellets, since none is found in the intestines, though this habit has not been observed.

As Moreau has pointed out, a large proportion of the ticks are swallowed unbroken, and though most of the tick is subsequently digested away, the shield remains. The wings of *Diptera* also are not digested. Nearly all the stomachs when examined fresh contained a brown fluid, which on microscopic examination proved to consist of semi-digested blood corpuscles and epithelial scurf cells. In two stomachs a small piece of skin with hair still attached was found, and in another stomach six very large blood clots were present. From the shape and size of these clots they were clearly not derived from a digested tick as were the blood clots found by Moreau, but had been ingested either as a clot from an open sore, or else taken as free blood which had clotted in the stomach.

There was no evidence of the birds having eaten small fragments of meat as Jackson (loc. cit.) suggests, though this author also wrongly suggested that "ticks, if at all, form an infinitesimal portion of its (the birds') food". In three of the stomachs, grass seeds,

grass awns and a small stone were found, and the birds apparently feed by feel, swallowing any small hard object which comes between their mandibles as they "scissor" through the hair. They must be very sensitive to such small objects in the hair, because some of the larval ticks swallowed were microscopic in size.

It is possible that hair and scurf are for some reason necessary adjuncts to the diet of ticks and flies, because at Kabete, the birds visit, every afternoon, stables where the cattle are stalled permanently for the production of red-water serum. These cattle are stabled and stall-fed from the day of birth, are never allowed out to pasture, and are completely tick-free. In spite of close examination of these stalled beasts I have found nothing on their bodies off which the birds could feed, except hair and scurf, and yet the birds industriously "work" the hides of these cattle every day, clearly swallowing material that they find. Birds shot in these stables invariably had ticks in their stomachs, which must have been obtained from beasts out to pasture nearby.

At Kabete, there is also a hide-drying shed, and birds may usually be found working over any fresh hides hung up to dry, but I am not certain what food they obtain from these. Even more interesting, however, is the flock of tick-birds which frequent Nairobi abattoir. When the carcasses are flayed and hung up for inspection on the outside rails, the birds descend on them at once and work over them. Although I was not able to obtain any for stomach examination from here, I am certain from close watching of these birds that they obtain nothing beyond liquid food such as serum, lymph or blood from these carcasses. Occasionally the birds may be seen picking at the pools of congealed blood which have dripped from the carcasses to the stonework of the floor below. These birds will of course also be able to obtain ticks from the livestock held in the slaughter pens before killing. At the Veterinary Laboratory at Kabete, Oxpeckers have also been noted feeding off fresh meat hung up by the slaughterhouse.

Included in Table III are records taken from skin data in the Coryndon Museum in Nairobi, which, though not quantitative, show that ticks and hair were included in all the stomachs examined.

Food of Buphagus a. africanus (Linnaeus).

Through the courtesy of Mr. L. A. Haldane of the Tanganyika Administration, I have been able to examine the stomach contents of seven birds of this related species. Their food resembles that of the Red-billed Oxpecker very closely, though *Diptera* were not found in this small sample. (Table II.)

The Nature of the Sores on Livestock.

On one bull at Kabete, there were a number of sores which were constantly attacked by tick-birds, and these were examined closely to determine their nature.

The sores on this bull were 19 in number, and were situated all along the spine, and on the rump at the base of the tail. Each sore had been worked by the birds into a shallow saucer-shaped depression almost perfectly round, and varying from ½ in. to 3 in. in diameter. The edges were perfectly smooth, and each sore varied from 2-3 mm. in depth. The bottom of each sore was also perfectly smooth, with no evidence of peck-marks, though in the bottom of the largest sore there were two deeper conical depressions. The whole abrasion scarcely penetrated to the underlying dermal layer, and there was no evidence of pieces of meat having been picked out, the whole having a smooth, moist serous surface. A certain amount of yellow fatty material was found in each hollow, and a small amount of congealed blood; there was no evidence of infestation by fly eggs or maggots on which the birds may have been feeding. The hair was not picked away from round each sore, which in fact were partly covered. There was no sepsis, and touching the raw surface of the sore did not appear to irritate the bull.

This description applies to all the sores on other animals which were examined, on which the birds were observed feeding, and the evidence suggests a type of liquid serum or blood feeding from these sores by the birds. It was interesting to note that on this bull, there was a good deal of demodectic mange on the tail, which did not appear either from observation of the surface, or from watching the birds at work on the bull, to be attacked at all. Though the skin surface in this region had many long cracks with congealed blood in them, the birds paid no attention to these.

Preference for Certain Animals in a Herd.

Many of the returns received stated that the birds showed preference for certain animals in a herd, on which to perch and feed. Firstly undipped stock was frequented most, then animals in poor condition; but even in herds of similar animals, whether dipped or not, there are still particular beasts which attract

more birds than others. From close watching of many such cases, I can offer no explanation why this is so; it appears to have nothing to do with colour (though chestnut and red animals are frequented slightly more often), or detectable odour, or hair and skin texture. Experiments to determine whether taste of the hair had anything to do with it were carried out by smearing salt solution patches on various beasts, but the results were quite inconclusive.

In the redwater stables at Kabete, mentioned above, the birds nearly always frequented most a big red steer. This animal appeared on close examination to be in no way different from any of the other twenty-odd cattle in the stable, except that he was very slightly taller than ones stabled nearby, though not more so than others stabled some distance away. This preference is a most puzzling question.

Observations on Feeding Habits.

As Moreau (loc. cit.) has observed, the Oxpeckers have no partiality for special parts of the body, except where sores occur, and there is no evidence of a definite feeding time, the birds being found on the stock herds from dawn until dusk. In the redwater stables, however, a flock of 30-40 birds nearly always arrived in the stables at 1530-1600 hours, though odd birds would come in at other times of the day.

The method of feeding is quite characteristic, the bird clinging closely to the animals hide with its long sharp claws, and using its beak with a side to side scissoring motion through the hair, the head being held parallel to the hide. Usually two or three sweeps are made in one region then the bird moves somewhat jerkily across the hide to try elsewhere, having raised its head first to swallow any food collected in the beak. There is no evidence that ticks are picked off individually or individually looked for, the scissoring being quite indiscriminate; as the stomach contents show, the birds will swallow anything hard they feel in the hair. Moreau has aptly remarked that Oxpeckers are somewhat unpleasant to watch feeding, having something about them of the persistence of blue-bottle flies on a piece of meat.

When feeding on an open sore, the feeding motion is very similar, with the head inclined parallel to the skin and the beak nibbling rapidly with a scissoring motion on the surface of the sore, as if squeezing serum from the clotted surface.

At Kabete in the grounds of the Veterinary Laboratory, there is a small paddock in which two experimental camels are kept. By tethering these animals and putting a hide nearby, I was enabled to watch the birds at very close quarters, and make still and cinematograph records of their behaviour. The camels were frequented by a score or so of tick-birds all through the day, and were quite free of ticks on their hides; but they had a number of open sores on them which the birds worked over daily, sometimes leaving one altogether until it healed up, and opening up others elsewhere on the body.

On several occasions while watching from the hide, I observed the Oxpeckers deliberately peck open a half-healed sore with a pick-axe like motion of the beak quite unlike the usual scissoring, and then continue nibbling and pecking at the sore until the blood was flowing freely. Then the birds could be seen clearly to swallow the free-flowing blood, the swallowing movements being readily seen at a distance of less than 6 ft. from the hide.

Sometimes if the sore was near ground level, the birds would stand on the ground to peck at it. Flies were caught in mid-air as described previously, but sometimes the bird caught these without leaving its perch on the camel's back, and the snap of the bill could be heard distinctly.

On these camels, the sores were worked over by the birds every day, usually more so in the afternoon, and particularly if the weather was sunny and hot. Dull, cold weather appears to make the birds sluggish, and they do not feed so readily. It could clearly be seen that each sore was nibbled at until the blood flowed freely, and it is of interest to note that only one bird at a time would feed on a sore. The others perched on the animal round about, and after a few minutes or so another bird would drive off the feeding bird with an open-bill threat attitude and a flutter of wings. Sometimes the birds would nibble at a sore while hanging upside down above it, but once the sore dries up they will leave it.

This sore-feeding did not appear to inconvenience the camels in any way, although some of the wounds were quite raw, and perhaps re-opened each day by the birds. Although a considerable number of *Stomxys* were round the camels all day, the birds preferred sore-feeding and only occasionally would they catch the flies. Sometimes the birds will squabble over an open sore, but there

appeared to be no special order of precedence among the feeding birds. Sheep in this same paddock were occasionally used as food hosts, but the camels were preferred.

A point of interest which requires clearing up is the nature of the food given to nestlings. Unfortunately I was not able to make any observations on this point. Jackson (loc. cit.) records parent birds bringing to a nesting hole with chicks, discrete food in their beaks resembling caterpillars or grubs. If these are the staple diet of the chicks, and not regurgitated ticks, it argues a complete change of food-collecting behaviour on the part of the adult birds at nesting time, and also a change of feeding behaviour by the chicks when they start feeding themselves.

General Behaviour, Call Notes, Roosting, Nesting.

Oxpeckers will never defecate directly on to an animal's hide, but lift the tail when doing so and shoot the fæces well clear of the living perch. They also defecate on the wing. They often spread themselves close to an animal with wings outstretched and lying on their sides, as if to get the maximum surface of the body in contact with the hide, a habit noticed by Moreau (loc. cit.). They will also use an animal as a preening perch, and take some time over their toilet; but they may also form preening parties on a tree trunk or fence. Dust baths on the ground are frequently taken.

Tick-birds are certainly social birds, when not nesting, and are found in flocks of two to three up to 20 or more. In these flocks I could determine no form of social hierarchy. The attitudes Oxpeckers adopt are quite characteristic, the commonest being a penguin type of posture, with upraised neck and bill giving the appearance of looking down their noses. This posture is commonly adopted after alighting and may be a recognition signal for the species. Another attitude is hunched up with beak pointing down, and this appears to be a threat attitude adopted towards another bird. The way they appear to slip and slide all over an animal's hide, on the back, flanks and belly is quite extraordinary to watch, but the long sharp claws are well-adapted for such a method of progress over a hairy surface. The call note between birds is a quick repeated "trix", often used on the wing, and the alarm note usually a "trick-quissss"—the latter part a hissing rattle often used when suddenly alarmed. Game animals used as hosts clearly understand the meaning of this latter call, and are put on the alert immediately. Often when approached on a beast, the birds will slide down the far side of an animal, and peer over its back at an intruder. Among the flock on the Kabete camels, there was one young bird (July, 1947), in plumage like the adult but distinguished by the dull red of the beak, which had also a black tip, a dark brown eye (not orange like the adult), and a narrow pale yellow eye ring, not wide and orange like the adult. This bird was otherwise in full plumage and well able to fly. It constantly accompanied the adults, and made a continual begging squeak "tit-tit-tit—tit-tit-tit", begging with wing-quivering from any adult which happened to be near. It made no effort to feed itself in the adult fashion, nor did I observe the adults at any time feeding it. One adult was watched pulling beakfuls of hair out of the camel's flanks, but not swallowing them, but the chick nearby made no effort to take these from the adult.

At Nyeri, the Oxpeckers are very partial to perching on the black and white wind-sock at the airfield. Possibly the feel and motion of it resemble a true live perch. They exhibit also a predilection for perching on chimneys, the dark hole in the centre appearing to interest them. It was reported by one observer that cats will not eat a freshly killed tick-bird, and this I have verified for myself. Oxpeckers do not seem to have any predators in the adult stage.

Oxpeckers are colonial roosters at night, and have been reported roosting in flocks in eucalyptus trees (Naivasha, Kinangop), cedar trees (Kinangop), other hollow trees (Kinangop), olive trees, roofs of buildings and rocks (Machakos), hollow trees (Ndaragwa), other trees (Songhor), banana trees (Kipkarren, Endebess), *Macrocarpus* trees (Muhoroni) and *Draceana* palms (Ruiru). At roosting time the birds pile in on top of one another like starlings going to roost in England. Usually the same roost is used year after year.

One observer from Muhoroni sent an interesting record of a large roost in about half an acre of edible *Canna*, not more than 3-4 ft. high. He informed me that these *Canna* are about 300 yards from the cattle sheds and that he spent one evening from about 5.30 p.m. to dusk at 7 p.m. watching the arrival of birds to roost. The average arrival was six flocks per minute, the flocks varying in size from six birds to about 50. The larger flocks were not common, the average being 15-20 birds per

flock. An African living in a hut by the *Canna* stated that the birds kept arriving up to about 9 p.m. on some nights. One night all the birds suddenly left this roost, and were not seen again for months until May, 1947, when they started concentrating again; but the *Canna* were then dug up and the birds again left. Jackson (loc. cit.) records them as roosting in large trees by the Luru River, small lots of 3-4 birds departing to seek their host animals shortly after sunrise.

Oxpeckers nest in holes, usually in trees (Kinangop, Machakos—dry season) or in the eaves of barns (Kinangop, May), under the roof trees of outhouses (Nyeri), under the gables of wood and iron houses (Nyeri), in chimneys (Thika). The Masai and Nandi tribes know well that they nest in hollow trees (Gilgil, Kipkarren). Usually they use the same nesting place each year.

One nest in the Nyeri district was composed of sticks and grass, very large and untidily built, the bird dropping much material below the nesting site. The birds have been reported pulling wool from sheeps' backs to carry to their nests. The only nest I personally have seen was in a hollow split in a *Macrocarpus* tree about 20 ft. up. The split was about 1 ft. deep in the tree, and the nest at the bottom was a very neat round cup made of reddish animal hair only. This was in July, 1947, at Kabete, and the nest remained empty and completed for several days before the full clutch of two eggs was laid. Unfortunately I was unable to keep full notes on this nest. One observer at Gilgil reported seeing them going in and out of holes in sandbanks, though whether they were nesting or roosting in these was not known.

Control Measures.

Although considerable attention has been paid in this study to sores and methods of sore-feeding by the birds, it must be emphasized that sore-feeding is an unusual type of behaviour, which is not exhibited by the birds unless easy opportunities exist, and that the staple food of Oxpeckers in general is undoubtedly ticks and flies. There is therefore general agreement amongst most observers that control measures for the birds are not necessary in most instances; the birds having disappeared as a result of dipping, or else being so few in number as to be not worth attention. Where sores are attacked by the birds, however, it is agreed that the first essential is to keep livestock in good healthy condition, and all horses well groomed, since healthy livestock are less prone to be attacked. For the treatment of such sores, and to discourage the birds attacking them, most farmers agree that applications of thick grease or Stockholm tar are sufficient; the sores heal up readily once the birds are kept off them.

When the birds are present in such numbers that they require to be controlled, destruction of nests and eggs, and shooting seems to be efficient (Nanyuki, Gilgil, Muhoroni), or simple scaring off can be tried (Naivasha); but occasionally even shooting is insufficient with persistent birds (Muhoroni). One farmer on the South Kinangop suggests trial of an ingenious trap to catch the birds, based on their predilection to sit on chimneys and such hollow structures. He recommends as follows—set up a 6-in. diameter stove pipe as high as is practicable (15 ft. or more) in the middle of the cow *boma* at about 4 o'clock in the afternoon. A *boma* away from trees or other tall perches is required. An Oxpecker will perch on the pipe, and on the approach of another he dives down the pipe and is unable to fly out again. The second will then do likewise when another bird threatens to push him off. I do not guarantee that this will work elsewhere, but can only state that an old pyrethrum drying shed of mine caught many birds down the 6-in. chimney, and kept the flocks well down in numbers. It used to cause much amusement amongst our milkers to watch the members of a new flock chatter on the chimney and then take a header down it, to be followed shortly by another and another. I have not tried this myself, but it is an ingenious suggestion well worthy of a trial.

In view of the emphasis laid by most of the questionnaire returns on the effect of dipping on the birds, it would appear therefore that with the extension of dipping practice, so advisable on other more important grounds of disease-vector control, the damage done to stock by birds will disappear also, more slowly perhaps in areas adjacent to undipped native reserve areas. Little more than local control is required to protect individual animals.

ACKNOWLEDGMENTS

I am gratefully indebted to all those District Veterinary Officers who undertook the distribution of the forms, and especially to the stockowners and farmers, too numerous to mention by name, who filled in these forms so carefully for me with full information.

To Mr. L. A. Haldane of the Tanganyika Administration I am indebted for the supply of *B. africanus* stomachs for examination: to Mr. A. J. Wiley of the Veterinary Research Laboratory, Kabete, I am especially grateful for his painstaking and careful identification of the ticks sorted out from the stomachs; Mr. A. J. Wiley, Mr. W. P. Langridge, Mr. J. G. Williams, and Mr. S. J. K. Collins gave much help in collecting birds and assisted in the observations; Mr. R. E. Moreau was always ready with helpful advice; and finally I am indebted to Dr. H. S. Purchase and Mr. J. R. Hudson of the Veterinary Laboratory, Kabete, for constant interest and advice in the work. Mr. E. Beaumont, Director of Veterinary Services, Kenya Colony, also gave much help and interest and to him I am indebted also for permission to publish these results; this work was carried out while holding a previous post as Zoologist in the Central Veterinary Research Institute at Kabete, Kenya Colony.

REFERENCES TO LITERATURE

Jackson, Sir F. J. (1938).—"Birds of Kenya Colony and the Uganda Protectorate." London, England. Vol. 3: 1301-1305.

Moreau, R. E. (1933).—"The Food of the Red-billed Oxpecker *Buphagus erythrorhynchus* (*Stanley*)." Bull. Entomol. Res. 24: 325-335.

APPENDIX

Red-billed Oxpecker (Tick-bird) Investigation

In an investigation in Tanganyika 14 years ago, it was found that of 58 Oxpeckers examined, 55 contained over 2,000 ticks in their stomachs; of these ticks 95 per cent were found to be species that carry east coast fever or heartwater, and it was concluded that probably on balance these birds did more good than harm. There have been no further investigations since that date, however, and recently there have been an increasing number of complaints about the damage done by Oxpeckers in producing open sores on the skins of cattle and horses. In order finally to settle the status of these birds as either harmful or beneficial to livestock, the Veterinary Laboratory is conducting an investigation of them, and your co-operation in filling in this inquiry form would be gratefully appreciated, together with any other notes on this bird which may be of interest.

Name .....

Locality and altitude (approx.) .....

Type of country—open plain/scrub/thorn bush/forest .....

Are Oxpeckers present in your district all the year? .....

Have they increased/decreased in numbers during the last few years .....

If you practise dipping, spraying or hand-dressing of livestock, have the birds increased/decreased since this was started? .....

Has damage by the birds in the way of sores on the hides increased since dipping was started? .....

Do you think the birds themselves start the sores on the hides? .....

Are the birds commonest on cattle/horses/sheep/goats/pigs in your area? .....

Do you personally consider them harmful/beneficial? .....

Any other notes of interest on habits, roosting, nesting, abundance, local movements, methods of control, or game animals used as hosts .....

If it is possible to collect any of these birds for examination of stomach contents from your district they would be gratefully received. The stomachs should be cut out, or the bird sent whole after slitting the abdomen, and packed in some watertight container containing weak formalin or spirit. Containers are obtainable at your local Veterinary Office.

They should be sent to Dr. V. D. van Someren, Zoologist, Veterinary Laboratory, P.O. Kabete, to whom also this form should be returned.

Any help you can give to make this inquiry as complete as possible would be most welcome.

TABLE I.—STOMACH CONTENTS OF *BUPHAGUS ERYTHRORHYNCHUS ERYTHRORHYNCHUS*

No.	Date	Locality	Sex	Gonads	Ticks								Lice		Flies				Miscellaneous
					Boophilus annulatus decoloratus	*Rhipicephalus evertsi*	*Rhipicephalus pulchellus*	*Rhipicephalus appendiculatus*	*Rhipicephalus simus*	*Amblyomma variegatum*	*Hyalomma* sp.	Unidentifiable	*Linognathus Vituli*	*Haematopinus* sp.	*Musca* sp.	*Fannia* sp.	*Stomoxys* sp.	Unidentifiable	
1.	17–3–47	Kabete pasture	*F*	small	4 *F* 5 *M* 7 N.	2 *F*	1 *M* 5 *F*	2 *M*		1 *M*		14	18					+++	*Aristida* seeds 5. 1 piece of skin with hair. Hair +. Brown fluid +.
2.	17–3–47	Kabete Redwater stables	*M*	small				3 *M* 1 *F*							26	1		18 +++ +	Hair ++++. Brown fluid +.
3.	17–3–47	Kabete Redwater stables	*M*	half enlarged				1 *F*									1		Hair +.
4.	17–3–47	Kabete Redwater stables	*F*	small											22			33 ++ ++	Hair ++.
5.	17–3–47	Kabete Redwater stables	*F*	small				4 *M* 3 *F*			1 N.				2		2	3 +	1 piece of skin with hair. Hair ++++. Brown fluid +.
6.	17–3–47	Kabete Redwater stables	*F*	slightly enlarged				2 *F*									4	1 ++	Hair +. Brown fluid +.
7.	26–3–47	Kabete Redwater stables	*M*	small	10 *F*	1 *F*		4 *M* 6 *F* 4 N.		4 *F* 6 N.		1					+	+	Hair ++. Scurf cells ++++. Digested blood corpuscles +. Brown fluid +. Mites sp. 2.
8.	18–4–47	Ol Kalou	?	?	9 *F*			22 *F*				19					1		Winged termites 21. Hair ++. Brown fluid +.
9.	24–5–47	Nairobi	*M*	enlarged	3 *F*		2 *M* 26 *F*	1 *M* 6 N.				2		11			11	6	Small moth 1. Grass seed 1. Grass awns 1. Hair +. Brown fluid +.
10.	19–8–47	Solai	*M*	small					3 *F*		1 *F*						2		Large blood clots 6. Serum clots with hair 3. Hair ++. Scurf cells ++++.
11.	19–8–47	Solai	?	?					1 *F*										Hair +++++. Scurf cells ++++. Small stone (diam. 1 mm.) 1.
12.	19–8–47	Solai	*F*	small								1			1		6	22	Hair + Scurf cells +.
			TOTALS ..		38	3	34	59	4	11	2	37	18	11	51	1	27	83	

NOTE.—N =nymphal stage. +—number of + indicates relative abundance.

THE RED-BILLED OXPECKER AND ITS RELATION TO STOCK IN KENYA

Red-billed Oxpeckers on camel's leg. The centre bird is re-opening a sore on the back of the leg with the pick-axe motion of the beak.

Red-billed Oxpecker, on the ground about to attack the sore on the "ankle" seen just in front of its beak.

THE RED-BILLED OXPECKER AND ITS RELATION TO STOCK IN KENYA—(*Contd.*)

Red-billed Oxpecker on camel's hump, using the hump as a preening perch. An open sore attacked by the birds may be seen below and to the left of the hump.

Red-billed Oxpeckers. Preening party on tree trunk.

THE RED-BILLED OXPECKER AND ITS RELATION TO STOCK IN KENYA—(*Contd.*)

Red-billed Oxpeckers. The "penguin attitude" after alighting on the camel.

Open wound on the back of a bull attacked by Red-billed Oxpeckers, showing the smooth inner surface and clotted blood.

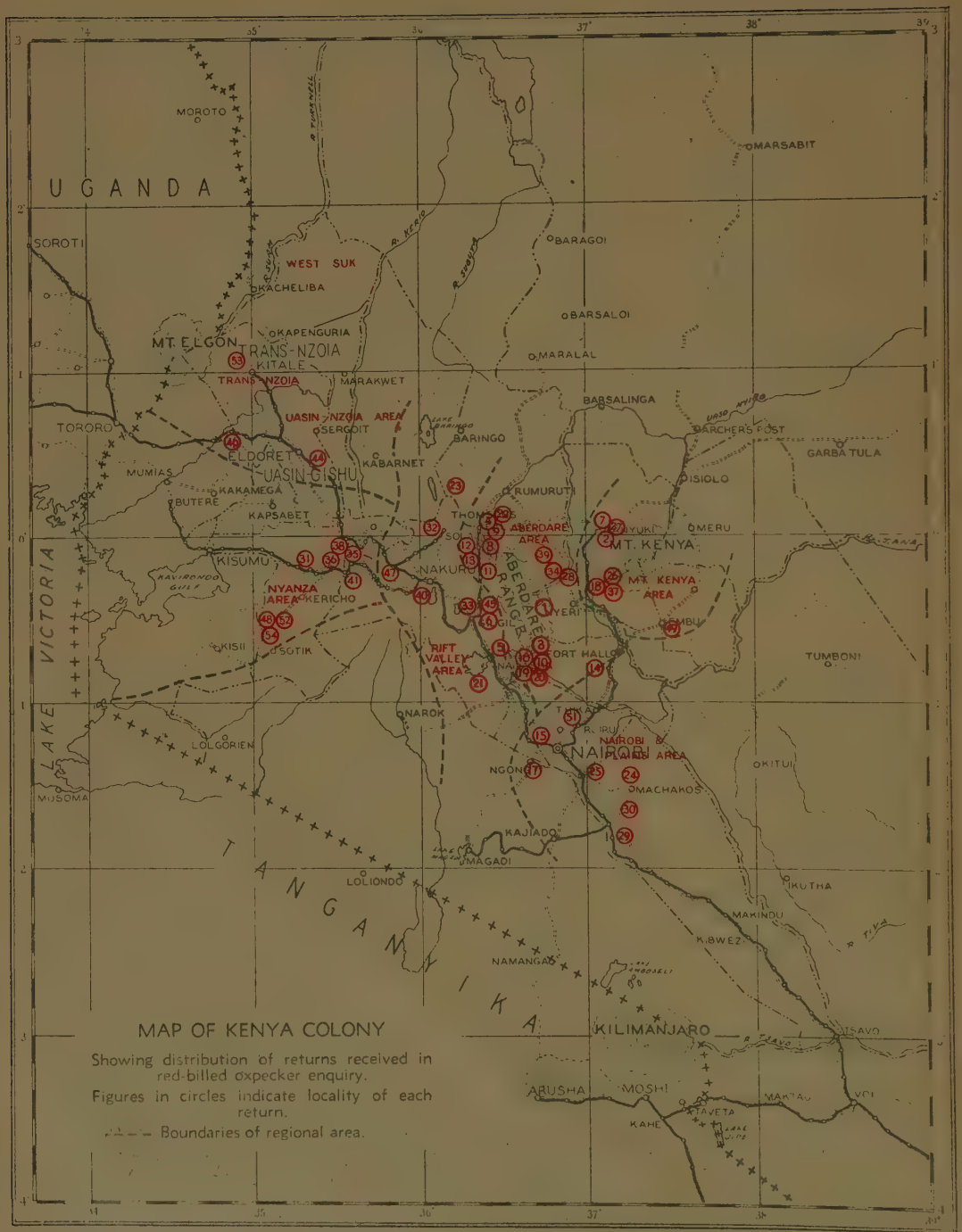

UGANDA
MOROTO
SOROTI
WEST SUK
KACHELIBA
MT. ELGON
KAPENGURIA
TRANS-NZOIA
KITALE
TRANS NZOIA
MARAKWET
UASIN-NZOIA AREA
SERGOIT
TORORO
ELDORET
KABARNET
MUMIAS
UASIN-GISHU
KAKAMEGA
BUTERE
KAPSABET
BARINGO
BARAGOI
BARSALOI
MARALAL
MARSABIT
BARSALINGA
ARCHER'S POST
GARBA TULA
ISIOLO
RUMURUTI
THOMSON'S FALLS
ABERDARE AREA
MERU
MT. KENYA
MT. KENYA AREA
KISUMU
NAKURU
ABERDARE RANGE
NYANZA AREA
KERICHO
NYERI
KEMBU
KISII
OSOTIK
RIFT VALLEY AREA
FORT HALL
TUMBONI
LAKE VICTORIA
NAROK
LOLGORIEN
MUSOMA
NAIROBI
NAIROBI & ENVIRONS AREA
OKITUI
NGONG
MACHAKOS
KAJIADO
TANGANYIKA
LOLIONDO
IKUTHA
MAKINDU
KIBWEZI
NAMANGA
KILIMANJARO
TSAVO
ARUSHA
MOSHI
KAHE
VOI
MAP OF KENYA COLONY
Showing distribution of returns received in red-billed oxpecker enquiry.
Figures in circles indicate locality of each return.
Boundaries of regional area.

TABLE II.—STOMACH CONTENTS OF *BUPHAGUS AFRICANUS AFRICANUS*

No.	1	2	3	4	5	6	7	Totals
Date	18–9–47	22–9–47	6–10–47	9–10–47	9–10–47	10–10–47	10–10–47	
Locality	Nyakisasa	Mihunda	Ngare	Bukiriro	Bukiriro	Rulenge	Rulenge	
Ticks: *Rhipicephalus appendiculatus*	1 *M*	8 *M* 10 *F*	6 *M* 4 N. 7 *F*	2 *M* 2 N. 3 *F*	14 *M* 10 *F*	2 *M* 13 N. 7 *F*	12 *M* 5 N. 6 *F*	112
Ticks: *Amblyomma variegatum*		4 N.	2 *F* 6 N.	6 N.	1 *M* 6 N. 2 *F*	2 *M* 25 N.	2 *F* 11 N.	67
Ticks: *Rhipicephalus simus*			1 *M*			2 *M* 3 *F*	1 *M*	7
Ticks: *Rhipicephalus capensis*						1 *F*		1
Ticks: *Ixodes* sp.						6 *F*	1 *F*	7
Ticks: Unidentifiable	145		67	35	+++	18	60	325
Lice						2		2
Hair	+	+++	++	+	++	++	+++	
Miscellaneous							1 seed *Bidens* sp.	

NOTE.—N=Nymphal stage. +—Number of + indicates relative abundance.

TABLE III.—STOMACH CONTENTS RECORDED FROM SPECIMENS OF *BUPHAGUS E. ERYTHRORHYNCHUS*, IN THE CORYNDON MUSEUM, NAIROBI

1. *M*, Songhor, 22–7–45. Ticks, hair.
2. *M*, Songhor, 22–7–45. Ticks, hair.
3. *M*, Kisumu, 22–7–45. 2 ticks, lot of hair.
4. *F*, Kisumu, 1–7–45. Ticks, hair.
5. *M*, Kisumu, 30–7–45. Ticks, hair.

BENZENE HEXACHLORIDE AND CHLORINATED CAMPHENE FOR SPRAYING CATTLE

By J. I. Taylor and E. G. McAnulty, Animal Health Research Centre, Entebbe, Uganda

In Uganda during the past two years or so techniques of spraying cattle have been developed in certain cattle areas; concurrently new insecticides have been synthesized which aim at a higher percentage kill and a more prolonged effect than those at present in use.

This paper compares the efficiency of a standard benzene hexachloride preparation with two new compounds of chlorinated camphene. The benzene hexachloride preparation used was Gammatox 3, a liquid which, when made up to the strength of 1:250 contained 0.01 per cent of the gamma isomer of B.H.C. Two preparations of chlorinated camphene were used; Toxaphene with a chlorine content of 65 per cent and made up in a dilution of 1:200 and Coopertox in dilutions of 1:250 and 1:150 having final Toxaphene contents of 0.33 per cent respectively. Dilutions of all compounds were prepared in the laboratory on the day of spraying and immediately taken to the spraying site some eight miles away. Standard pattern Eclipse Leader Senior spray pumps were used throughout the experiments.

In both experiments groups of five small East African Zebu cattle each containing the same number of adults and calves were used. These were taken at random from cattle which were in the habit of grazing together. These cattle had been sprayed with B.H.C. weekly for some months previously until a week prior to the experiment. Since, in the writer's experience, the counting of larvæ results in high experimental error, nymphs and adult ticks only were counted. Counts were made at the same time each morning. The area counted was from in front of the scapula bone, up the neck, the dewlap, the eyes, the ears inside and outside and the muzzle. Each side of the head and neck was counted separately, the division being the midline. Each day's tick counts were considered as the total number of ticks found in each group of five cattle.

Both experiments could be divided into two phases: (i) in which the actual tick-killing power of the insecticide, i.e. the percentage of ticks killed in 24 and 48 hours, was measured and (ii) in which the residual effect of the spray was observed.

Experiment 1.—Five groups of five cattle were sprayed as follows:—

Group 1. Toxaphene — 1:200.
Group 2. Gammatox 3 — 1:250.
Group 3. Coopertox — 1:250.
Group 4. Coopertox — 1:250—Gammatox 1:250 (equal parts).
Group 5. Control — Water.

In Groups 1-3 the spray was prepared to the dilution recommended by the manufacturers. Group 4 was inserted because all groups had been sprayed regularly with B.H.C. and may have been carrying a slight residue. It was considered desirable to ascertain whether any demonstrable interaction took place between the chlorinated camphene and the benzene hexachloride. Group 5, the control group, was sprayed with water. Fifteen pints of liquid were sprayed onto each group averaging three pints of spray per animal. Each animal was sprayed all over the body, particular attention being paid to the ears, belly udder, tail and heels.

This experiment was repeated (Experiment 1 (*a*)) in exactly the same way in a different area seven miles away, with a further twenty-five cattle.

Experiment 2.—In this experiment the groups were arranged as follows:—

Group 6. Gammatox 3 — 1:250.
Group 7. Coopertox — 1:250.
Group 8. Coopertox — 1:150.
Group 9. Control — Water.
Group 10. Control — Handpicked.

Groups 6, 7 and 9 replicate Groups 2, 3 and 5 in Experiment 1. Group 8 was inserted to measure the effect of increased concentration of Toxaphene. Group 10 was not sprayed but on the day following the spraying of Groups 6-9 the five animals in Group 10 were de-ticked by hand. The object was to ascertain the time taken for ticks to establish themselves, in numbers equivalent to that of the controls, on a tick-free unsprayed group. It was considered that this, compared with the rate of build-up in the sprayed groups, would give a truer indication of the residual effect of the insecticides.

This was felt to be necessary as it was noticed that after routine spraying with B.H.C. some measure of tick build-up took place almost immediately.

Results

Phase 1: *Tick Kill.*

In every case, the ticks involved were *Rhipicephalus appendiculatus*. For the purpose of estimating the tick kill identical groups in Experiment 1, Experiment 1 (*a*) and Experiment 2 were considered together. These results are shown in Table I from which it will be seen that the tick kills were satisfactory for all the insecticides. It appeared that the tick kill with the chlorinated camphene groups was quicker than with the benezene hexachloride. With the benzene hexachloride group the maximum effect occurred 24 to 48 hours after spraying.

Experiment 2.—As in Experiment 1, the ticks found were *R. appendiculatus*. The results of Experiment 2 are shown in Figure 2. In Group 6 it will be seen that, following spraying with Gammatox 3, the tick count returned to the control level in six days. This was in agreement with the results of Experiment 1. The spraying. In Group 3, Coopertox 1:250, on the ninth day after spraying, the tick count, although still very slightly below the initial level, was such that respraying was considered advisable. The Coopertox-Gammatox mixture, Group 4, gave results very similar to the Coopertox alone, and it can be concluded, therefore, that no interaction occurred between the two insecticides and that it is perfectly safe to spray a chlorinated camphene after a prolonger period of spraying benzene hexachloride.

TABLE I

Table Showing Tick Kill of Various Insecticides at 24 and 48 Hours after Spraying

Insecticide	No. of animals per group	No. of ticks per group before spraying	No. of ticks per group after spraying		Per cent tick kill	
			24 hours	48 hours	24 hours	48 hours
Toxaphene 1/200	10	3,006	438	374	85·4	87·6
Coopertox 1/250	15	3,539	340	263	90·4	92·6
Coopertox 1/150	5	1,401	114	97	91·9	93·1
Gammatox 3 1/250 ..	15	3,799	1,147	909	69·8	76·5
Mixture Coopertox—Gammatox	10	2,681	342	259	87·2	90·3

A Chi-squared test on the results at 24 and 48 hours shows that although there is a significant difference between the killing power of the chlorinated camphene groups and the benzene hexachloride, no such difference exists between the individual sprays of the chlorinated camphene group.

It was found that the ticks remaining after spraying were generally on the ears in inaccessible folds which the spray had probably not reached.

Phase 2: *Residual Effect.*

Experiment 1.—In this experiment all ticks found were *R. appendiculatus*. The results from the two areas were almost identical and have been combined in Figure 1. In Group 2, Gammatox 3, the tick counts were up to the control level on the sixth day after spraying and in Group 1, Toxaphene, on the seventh day after tick build-up both for Coopertox 1:250 and Coopertox 1:150, Groups 7 and 8, was much slower. Of these two groups the latter carried rather fewer ticks up to the sixth day. From the seventh day after spraying the group sprayed with the 1:250 dilution showed a steady rise in tick numbers and the control level was passed on the ninth day. The 1:150 dilution appeared to have a further two days residual effect, after which a considerable increase in the tick count brought the level up to that of the control on the tenth day after spraying. As will be seen from Figure 2 the build-up of ticks which followed hand-picking in Group 10 was much more rapid than in the sprayed groups. This amply demonstrated the fact that these sprays had a residual effect, although, even from the second day after spraying the protection was not absolute. The control group, Group 6, kept a satisfactory

FIG. 1. GRAPH SHOWING EFFECT OF BENZENE HEXACHLORIDE AND TOXAPHENE ON TICKS. EXPTS. 1 & 1a.

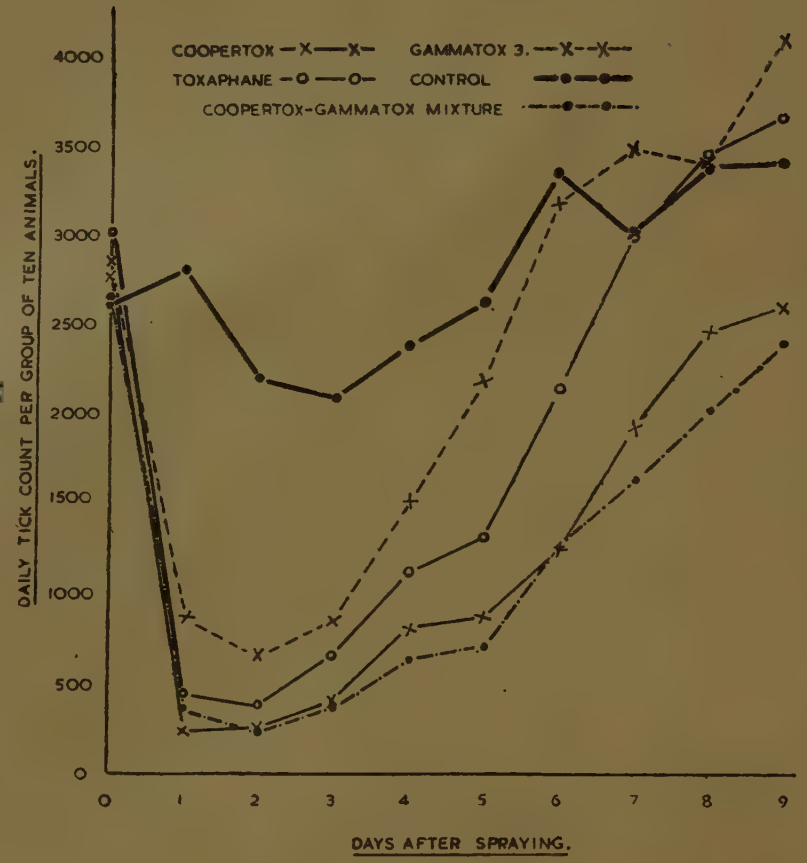
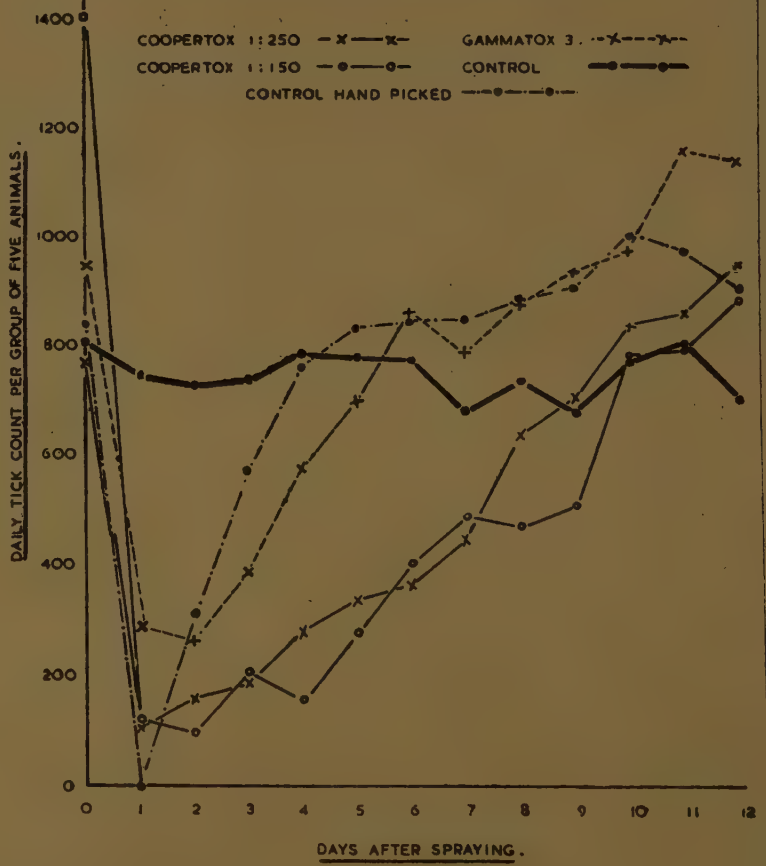


FIG. 2. GRAPH SHOWING EFFECT OF BENZENE HEXACHLORIDE AND TOXAPHENE ON TICKS. EXPT. 2.



steady level throughout the experiment and the rainfall of 3.9 inches which took place during this period appeared to have little influence on the tick counts.

No ill effects on the animals were observed following spraying with any of the insecticides at any of the strengths used nor did there appear to be a reduction in milk yield.

Discussion

Benzene hexachloride may be satisfactorily used in a dip (Worsley, 1950), and it is used extensively for spraying cattle in Uganda (Wilson, 1949). In the United States the extensive work on chlorinated camphene is summarized by Roark (1905) and as it appeared to have a greater residual effect than the benzene hexachloride, it was tested for possible use in spraying. It is difficult to ensure that African cattle owners will bring their cattle to be sprayed other than at the same day of each week. For this reason, therefore, it is necessary for a spray to be effective either for a week or unit of weeks.

The benzene hexachloride spray does not give adequate protection for more than six days after spraying and ideally the cattle should be sprayed on the sixth day. The residual effect of the chlorinated camphene lasts longer, and at the strength of 1:150 protects for up to ten days. The tests carried out were admittedly severe for the insecticides, in that the amount of spray used was small (three pints) and the results were recorded after only one spraying. Evans (1951) states that there appears to be a build-up or cumulative effect with Coopertox over a series of sprayings. The results obtained, therefore, from the spraying of chlorinated camphene at sufficient strength can be regarded as very satisfactory. It should be pointed out, however, that the protection of all the insecticides used is relative, that is, it is not a complete protection against ticks, but is a protection against a massive tick build-up. It should be noted, however, that with the large tick populations involved it was only possible to count attached ticks and no attempt was made to assess the number which failed to engorge. It would appear from the above, therefore, that chlorinated camphene might be used for spraying at fortnightly intervals while benzene hexachloride should be used at intervals of a week.

REFERENCES

[1] Evans, S. A. (1951).—Personal Communication.

[2] Roark, R. C. (1950).—"A Digest of Information on Toxaphene", U.S. Dept. Agric. Bull., E. 802.

[3] Wilson, S. G. (1949).—"Control of Ticks by Spraying", Ann. Rep. Vet. Dept., 1949, Uganda Protectorate, p. 26.

[4] Worsley, R. R. Le G. (1950).—"Benzene Hexachloride as a Cattle Dip", E. A. Agric. J., Vol. XV, p. 127.

BACTERIAL BLIGHT OF PEAS

By G. B. Wallace and Maud M. Wallace, Department of Agriculture Tanganyika Territory

(*Received for publication on 19th June,* 1951)

A destructive bacterial disease of field pea and sweet pea has appeared recently in the Northern Province of Tanganyika Territory. The identity of the bacteria concerned is not yet certain, but it is considered advisable to bring the disease to the notice of farmers, gardeners and others without delay. Material has been sent for identification to Dr. W. J. Dowson at the Botany School, Cambridge, and he has kindly undertaken investigation of the organisms present. His conclusions are awaited and will be communicated in a subsequent number of this Journal.

Two species of *Pseudomonas* have been found associated in the local disease, and one of these is pathogenic when inoculated into pea and also into Bonavist bean; the significance of the second species is uncertain. As the infective bacteria have much in common with *Pseudomonas pisi,* some information on that organism is given below. It is the cause of bacterial blight in peas in other countries, having been first found in the U.S.A. in 1915 [1], and later in Canada, Bermuda, Germany and Australia. Other host plants of that organism are Sweet pea, Everlasting pea, Cowpea and Bonavist or Hyacinth bean (Kiswahili, *fiwi*). Attempts made by V. Skoric [2] to inoculate twenty-two other species of legumes gave negative results, but one of them, Broad bean, is recorded as a host in Bermuda.

In Tanganyika the disease was first observed in field pea and sweet pea at the end of April, 1951, on a farm twenty-six miles from Moshi, and on two small plots one and a half miles away. In mid-May it was seen in a garden at Arusha, and in early June in one twelve miles from Moshi and fourteen miles from the above farm. In mid-June two gardens situated twenty miles beyond the affected farm had a little blight in the now mature plants. Other farms and gardens so far visited have been found to be clean.

On the affected farm over two hundred acres of peas were being grown for export. Seed had been imported from England four or five years ago with no ill effects. In early 1950 seed from two other countries were imported and sown; in one of these *Ps. pisi* is endemic and is the most likely origin of the outbreak in Tanganyika if that is the organism present. The disease was not observed here in 1950, but it must have been present in a mild form, to account for its presence this year. In late April the disease was observed by the owner of the farm as small leaf-spots and it was brought to the attention of the laboratory. The disease proved to be bacterial and one of the organisms isolated was found, as stated above, to be pathogenic.

The few affected plants in gardens at Arusha and in the Moshi district were immediately destroyed. The seeds from which the Arusha plants were grown are believed to have come from the affected farm; the plants near Moshi were almost certainly infected from contamination on the hands of the owner. The two gardens seen in mid-June were probably infected late by wind-borne dust or birds, etc.

When the disease was first observed on the farm referred to, it was already fairly distributed in most fields, but the plants were too large and inter-twined for spraying to be considered. Immediate destruction of the plants was not contemplated for the following reasons: A large amount of capital was involved; and there was the hope that the onset of dry weather would dry up the lesions on the plants thus restricting spread, and make roguing worth while. Also, owing to the fairly isolated site of the farm, a delay in recommending any drastic measures seemed justified. At the time of writing, however, continued rain and rapid increase of the blight, together with a plague of caterpillars have resulted in rotting or withering of the haulms of all the plants. The seeds which could be harvested are mostly small and very shrivelled and would weigh about two per cent of the original estimate of the crop. On their appearance alone most of them could not be sold as seed, though many could germinate. It is intended that they will be either destroyed or be consumed locally. The haulms are being collected and burned and the land will be deeply ploughed. Pasture grasses and fodder crops of immune species will be sown.

Officers of the Department of Agriculture were notified at once about the presence of the disease, and this was followed by a short article in a local publication reaching the majority of farmers, and a circular sent to all farmers in the Province.

Symptoms

Spread of the disease in a field is very rapid: in a period of about six weeks of wet weather the intensity can increase from a few isolated leaf-spots to blackening, decay and collapse of the plants on whole fields.

Symptoms can be seen in seedlings arising from infected seeds, and may appear on the first formed stipules and leaves. Leaf-spots show as few or numerous tiny brown dots or larger rounded areas of one-eighth to one-half inch in diameter and with either a definite or indefinite margin (Fig. 1). They are sometimes partly restricted by the larger veins. The infection may follow veins and it often shows round the margins of leaflets. The latter symptom appears when leaflets have been infected and gummed together along their margins by bacteria which have multiplied as a result of the dampness in the opening bud. The spots are at first water-soaked and translucent, but become olive-green to brown, later turning almost black.

On stems, petioles, tendrils and flower stalks longer brown areas are seen. Flowers are also affected with brown spotting, and pods show water-soaked or grey sunken lesions (Fig. 2). The disease can spread into the pods and reach the seeds, and these may show a bacterial slime and decay. As stems blacken and decay, the parts beyond wither, and finally the plants collapse and rot on the ground (Figs. 3-5). The effect is very much the same as that of Irish blight of potato, but with an earlier rotting of the stems. On old pea plants, and in dry weather, symptoms are not so easily recognized, but the water-soaked dark green to grey areas on pods remain obvious for a considerable time.

Infection by the organism *Ps. pisi* is recorded not to be systemic, and that appears to be the case here; i.e. the bacteria apparently do not spread along the vessels within the plant but cause separate infections when splashed by rain from leaf to leaf. In the same way the bacteria are spread from plant to plant. No doubt the bacteria are carried also by insects, birds, wind-borne dust and contamination of the hands and clothing, as well as by seeds. They can enter the stomata, and they enter wounded tissue readily. The disease is very much intensified by humidity.

It is sometimes difficult to distinguish spotting caused by the fungus *Ascochyta pisi* from the bacterial spots, particularly when they are small, and in mixed infections. The Ascochyta spots remain a darker brown and cause no water-soaking; also, when they become larger they are round and show rings on their surfaces. The fungus is very common in older pea plants and is not of major importance. When there is any doubt, leaves or pods should be sent to the laboratory for diagnosis.

Control

Control measures may be considered for clean areas, endemic areas and infected fields respectively.

As in the case of other seed-carried diseases, the chief preventive measure is to ensure that healthy seeds are obtained for sowing, i.e. seeds from fields, or better areas, from which the disease is known to be completely absent. Precautions against contamination will sometimes be advisable, e.g. from sacks, handling or other causes. Seed from a country in which the disease occurs should be accompanied by a certificate to the effect that they are free from the blight.

In endemic areas the risk of infection may render the culture of susceptible crops inadvisable on a large scale. Planting should in any case be restricted to the main growing season in the year. Immune crops would be preferable. Rotation with immune crops would reduce the danger of any soil infection. Wounding of plants, which encourages infection, is difficult to avoid in such a crop as field peas which soon form a dense cover; roguing and weeding are necessary, but so far as possible wounding should be kept to a minimum. Any measures which will reduce humidity amongst the plants will lessen the intensity of the disease, e.g. drainage, wide spacing, weeding and restricted irrigation.

When the disease has appeared in a field it would be well to obtain technical advice at once. It might be possible to control an outbreak on a garden scale if the disease is recognized early, by removing affected plants as they appear and by spraying the plot. On any large scale the rate of spread from an initial infection would be very largely determined by the weather; a period of dry, bright weather would to some extent dry up the bacterial lesions, but reliance cannot be placed on this for control. When the disease has appeared with any severity in a field the crop should not leave the farm and should on no account be used for seed, but be consumed as food. Care

should be taken to destroy all the contaminative haulms and trash including pods. If threshing machines are used, plants from clean fields should be threshed before those from any affected or doubtful ones.

Farmers in the Northern Province of Tanganyika are warned not to grow peas or any other susceptible species on any large scale while the present menace exists; the danger to themselves and the community is now obvious. If it is decided to declare the parasite a pest under the Plant Protection Ordinance, inspectors will be authorized to enforce drastic measures for control when the disease is observed.

Seed treatment is not recommended except for the destruction of superficial contamination, as it can have no effect on bacteria within the seeds. There may, however, be occasions when it is desirable, and results obtained by D. C. Wark [3] in Australia may then be of interest. Wark found during trials that the most effective bactericial solution he used for *Ps. pisi* was a 1:500 solution of mercuric chloride in 70 per cent ethyl alcohol, acidified with three per cent acetic acid plus 1 in 20,000 gential violet. It is recorded that seed of two varieties were treated for four hours in this solution and sown in the field. They germinated well and the number of plants showing primary infection per 2,400 seeds was 0 and 2 respectively, compared with 45 and 80 for untreated seed. This treatment is said to be impracticable against Halo blight of French beans as it causes considerable reduction in germination, although effective against the organism itself.

REFERENCES

[1] Sackett, W. G.—Agr. Exp. Sta., Colorado Agr. Col. Bul. 218, 3-43, 1916.

[2] Skoric, V.—Phytopathology 17, pp. 611-627, 1927.

[3] Wark, D. C.—J. Aust. Inst. Agric. Sci. 15, pp. 37-38, 41, 1949 (Rev. Appl. Myc. 18, p. 557).

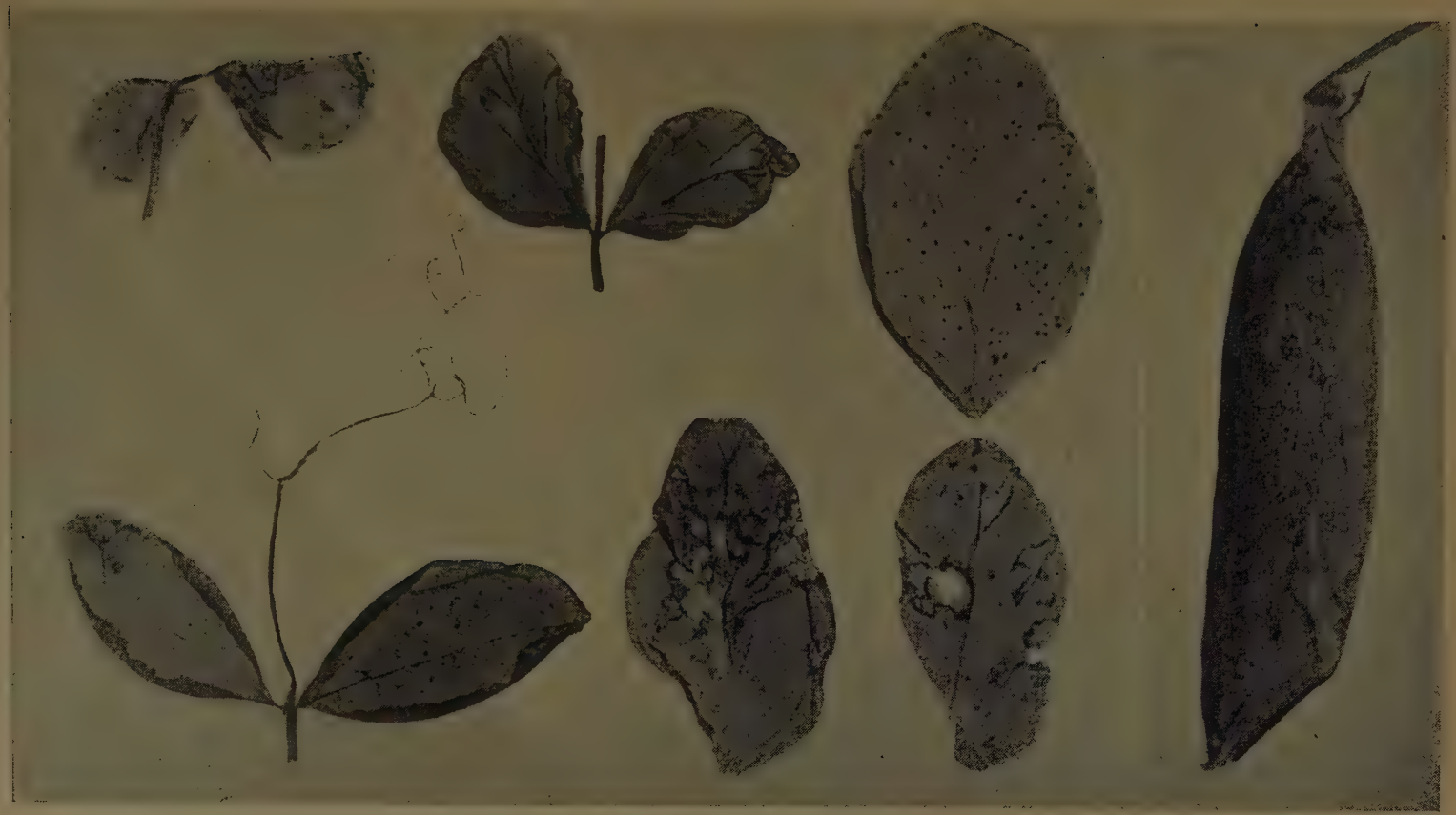


FIG. 1.—Pea stipules, leaflets and a flower with bacterial spotting.

FIG. 2.—Pea pod with spotting.

FIG. 3.—Leaf spotting and withering.

FIG. 4.—Withered leaves, and opening leaves gummed together at the edges by bacterial slime.

FIG. 5.—A late stage of infection; the leaves have rotted and fallen and two pods show dark lesions.

SUBSIDIARY SILVICULTURAL OPERATIONS IN TANGANYIKA

By F. W. Champion, Forest Department, Tanganyika

(*Received for publication on 4th May*, 1951)

It has long been the custom in well-managed forests of tropical countries for the main timber fellings to be followed by subsidiary operations designed to renovate the forests and bring them to as good a silvicultural condition as is consistent with reasonable expense. Such subsidiary silvicultural operations, carried out in India over a long period, undoubtedly did a very great deal to build up the magnificent forest estate, full of good straight trees of all ages, which was handed over by the British Government in 1947 to the Governments of India and Pakistan. The object of subsidiary silvicultural operations in natural forest is to improve the growing stock of all ages. Many of the operations included in the term require a considerable knowledge of the silviculture of the trees concerned. We do not yet possess this knowledge in East Africa where the control of forest cutting has so far been inadequate, owing largely to paucity of staff and shortage of funds.

The present system of exploitation in East Africa is liable to a number of disadvantages. The sawmiller may (and usually does) remove most or all of the good-quality, straight, sound trees of the valuable species, leaving only inferior, defective hollow and over-mature specimens to cover the ground and provide seed. Under the terms of the ordinary concession agreement, operating on a minimum girth limit, there is nothing to stop the sawmiller cutting every mature tree. This does in fact sometimes happen. The sawmiller seldom fells trees of inferior species, so that the usual type of felling removes the best trees of the best species, thereby favouring inferior species by giving them more space. These practices tend to increase the proportion of inferior species and to decrease the quantity and quality of the better species. The sawmiller is not required to protect the natural regeneration of the valuable species, or to keep climbers in check. Since forest departments have had insufficient money and staff to do this, natural regeneration has been largely neglected and climbers have increased in exploited areas.

The combination of these various factors has in many cases resulted in degradation of the forests whereas good forestry requires that they should be left in at least as good a silvicultural state after felling as before. With regard to this, it is the general opinion in Tanganyika that at least the greater part of the closed forests should be regenerated with the species which occur in them naturally and are known to be suited to the environment. There may be arguments for converting portions of the poorer forests into fast-growing exotic conifer plantations, but we should remember the fable of the hare and the tortoise, which has particular application now that it is evident that one at least of our reputedly slow-growing indigenous species, the valuable East African camphorwood (*Ocotea*), is by no means so slow as was once thought.

I wish to make it clear that the type of felling to which I have objected above is by no means peculiar to Tanganyika. It has occurred in the early stages of forest development in many countries. But the time has now come to raise the standard of foresty practice, and two ways in which this can be done are, firstly, to adopt subsidiary cultural operations as routine practice and, secondly, to replace the present system of more or less automatic felling of all sound trees above an arbitrary girth limit by a system of silvicultural marking. It must however be remembered that subsidiary silvicultural operations cost money, and that the forests are large. The operations must therefore be selective, i.e. must be done intensively in valuable areas where their benefit is obvious, and less intensively in inferior areas where improvement of the growing stock is more difficult and, for the time being, less important.

Any or all of a considerable number of operations can be included under the broad term "subsidiary silvicultural operations" although in some countries certain of them are distinguished separately. The following works can be considered as falling within the scope of the term:—

(*a*) Felling or girdling of marked trees not removed by concession-holders.

(*b*) Felling or girdling of unmarked figs and other useless trees occupying too much space.

(*c*) Thinning of young groups of valuable species.

(*d*) Climber-cutting.

(*e*) Opening up and freeing valuable natural regeneration to give it more light and room.

(*f*) Coppicing healthy but stagnating or misshapen natural regeneration, and stems which have been damaged during exploitation.

(*g*) Controlled burning, where such has been proved to be advantageous and where it can be adequately supervised.

The number of marked trees to be felled or girdled will depend on how the original marking was done. At that marking either all trees whose removal is silviculturally desirable are marked and the contractor is bound to fell every tree so marked whether it contains timber of use to him or not, or only those trees both available silviculturally and believed to contain timber are marked for felling by the contractor and the removal of useless trees is left to the man in charge of the subsidiary silvicultural operations. In India, the original markings were usually done by officers or trained rangers of a higher standard than those in charge of the subsidiary operations, and usually all trees whose removal was considered necessary were marked by them for felling by the purchaser of the coupe, even if this resulted in a poorer price being paid for it. If such felling proved impracticable, the gang carrying out the subsidiary operations had to fell or girdle all marked trees left by the contractor, the choice between felling or girdling depending on a number of factors, including cost, insect and fire risk, damage to natural regeneration, danger of windfall, etc.

The removal of grossly overmature and useless large trees, including large figs (*Ficus* spp.), is a major problem in the rain forests of Tanganyika. These useless trees usually occupy far too much space and cast a very heavy shade: their removal may be essential, but will be expensive. Girdling is usually cheaper than felling, although not always as effective. In the case of camphor, felling is believed to be essential if root-suckers are to arise from the wide-spreading roots. Useless over-mature trees can be marked in the original marking although the purchaser will dislike having to fell them. They must, however, be disposed of somehow or other if the forest is to be improved and natural regeneration stimulated.

The thinning of younger groups of valuable species is usually best left to the discretion of the man in charge of the subsidiary operations, because such groups are often damaged in the main fellings and it is usually a waste of time to mark the thinnings beforehand. Thinnings of utilizable size should however be marked at the original marking so that the purchaser can have the benefit of such trees even though they may be smaller than the normal exploitable stem.

Climber-cutting may be done at the time of original marking for felling, or as a separate task, or as part of subsidiary silvicultural operations. In Tanganyika it is probably most conveniently done with the other silvicultural operations. Climber-cutting, especially when done for the first time, tends to be expensive. It should be selective (done only where climbers are damaging valuable trees or natural regeneration) and should not be attempted at all on steep slopes, where tree-felling is not desirable in any case. In the case of large climbers it is more effective to cut a section two or three feet long out of the base of the stem rather than to sever the stem with a single cut.

The assisting of existing natural regeneration is probably the most important of all subsidiary operations. Most natural forests contain trees of all ages and many species, some of which are valuable and some of which are not. A fair amount of natural regeneration of most of the species is generally present but there is a continual struggle for light and room. Some of the species are valuable for timber; others, often strong-growing and occupying too much space, are not. Subsidiary cultural operations aim at helping valuable species against their useless rivals. Therefore wherever natural regeneration of valuable species is present, it must be cleared of weeds, of competitors of less useful species, of overhanging branches and (if the stems are too close together) it must be thinned. The overhead cover, too, should be decreased, according to the light requirements of the various species, about which unfortunately we know little. As has been stated, one of the main objectives of cultural operations is to stimulate existing natural regeneration: another very important objective is to produce conditions which will stimulate the appearance of new natural regeneration. Experiments to that end have yet to be made in Tanganyika.

Coppicing operations are allied to the cleaning operations described above. Even good stands of natural regeneration frequently contain a number of crooked, stunted and badly

shaped young plants that have suffered from suppression throughout their lives. Provided that they are of a species which will coppice it often pays to cut back these young plants, preferably in groups, and to make gaps in the canopy above them to give them more light. This is skilled work requiring careful judgment, which can only be acquired by long experience. Valuable young trees which have been damaged during exploitation should also be cut back, if capable of coppicing, and be given enough light and room for new shoots to develop.

Controlled burning is sometimes used to clean up a forest after heavy fellings, both to remove inflammable debris and check weeds. It, too, is an extremely skilled operation, requiring expert local knowledge and careful European supervision. Although doubtless controlled burning has very considerable possibilities in East Africa, nevertheless fire is a double-edged weapon, dangerous to attempt to use without full knowledge and fully-trained staff. A series of experiments designed to study the effect of controlled burning as a stimulus or deterrent to natural regeneration would be valuable. It is known that young mvule (*Chlorophora*) is extremely fire sensitive, although it may coppice after being burnt, whereas East African pencil cedar (*Juniperus*) and some exotic cypresses appear to regenerate more easily after moderate fires than otherwise.

I have set out above some general principles concerning subsidiary silvicultural operations, but we have too little local knowledge to lay down hard and fast rules for their application in East Africa, although there is no doubt that silvicultural markings followed by subsidiary silvicultural operations should, and indeed must, be introduced as standard practice in many areas. To keep down costs, both operations (and particularly the subsidiary silvicultural operations) must be selective, varying from place to place according to the quality of the forest and the quantity of existing natural regeneration. In the case of silvicultural marking, maturity girths should be prescribed as a guide rather than a rule. Trees which are required for seed should be left unfelled, irrespective of their value to the sawmiller, and really good groups of well-grown young trees that have only just reached the girth limit may be retained until the next felling if they will benefit by a further period of growth. Marking and cultural gangs should be small (normally of not more than about 15 men) and should be in the charge of a trained ranger or forest guard working under the close and personal supervision of a European forest officer. The work undertaken at any one time should be confined so far as is possible to fairly compact areas to keep down costs and facilitate inspection. The intensity and details of the operations can only be decided by experience and by balancing the costs (at present largely unknown) against the benefits derived. It will, moreover, be necessary to proceed cautiously, since we know so little about the silviculture of even our most important trees. I myself have been in Tanganyika for two years only and therefore hesitate to express opinions on the silvicultural treatments to apply to any of its forests. I feel sure, however, that there must be a good deal of valuable information stored in the brains and notebooks of senior officers and I consider it of paramount importance that this should be collected and classified. Experiments should be laid out, also, to study the regeneration and rate of growth of our more important indigenous trees before we dismiss them as too slow-growing, and before we replace them—or at any rate neglect them—in favour of fast-growing exotic softwoods. From my very limited experience of silvicultural and natural regeneration work in this country, I would venture a few tentative observations in regard to subsidiary silvicultural operations in heavily felled camphor forest.

A natural forest of camphor which has never been thinned or cleaned usually contains many very large and misshapen trees. It may therefore legitimately be heavily felled, down to a comparatively small girth limit. Large old camphor must be cut whether or not they contain usable timber.

Felled camphor trees send up root suckers which appear to develop into good stems. In addition, the camphor forests usually contain a considerable proportion of regeneration of seedling origin. In view of the importance of the subject, immediate experiments are required to determine whether or not it is advantageous to isolate the young stems of root sucker origin by cutting the parent root on both sides of the young stem to form a new individual.

Camphor regeneration is often prolific and is usually mixed with good regeneration of mhaa (*Macaranga*) and milimangombe (*Rapanea*). It is usually found in groups, interspersed with patches of brambles, grass, shrubs

and inferior trees under which there is no regeneration of value. The camphor regeneration should be thinned to leave the stems at least nine feet apart and, since the species coppices well, all thinned stems should be cut cleanly at the base. Young camphor trees that have been damaged during exploitation should be cut similarly, as should all crooked and defective stems. Camphor should be favoured over regeneration of all other species and after it has been treated all competing growth should be slashed back.

Little or no pruning of camphor branches should be done as the saplings are usually not very branchy and there is always the risk of introducing fungal diseases. So far I have seen only one case of attack by honey fungus (*Armillaria*) in a natural camphor forest although the fungus has appeared in camphor plantations on Kilimanjaro.

Camphor appears to like a fair amount of overhead shade. A moderate to light canopy should be retained, particularly as excessive opening usually leads to very heavy weed growth. Large, leafy, useless canopy trees should however be girdled or felled.

As has been emphasized, it is essential that cultural work should be selective to keep costs within bounds. Natural regeneration is nearly always patchy, and intensive work should be undertaken only where there are good groups of it. Isolated young stems of valuable species should be freed where they occur, but no work should be attempted at present where there is no regeneration. At a later stage it will doubtless be possible to stimulate regeneration *de novo* in blanks. At the moment we have neither the knowledge nor the staff to try this.

Climbers which are damaging or likely to damage young camphor should be cut back selectively: the wholesale cutting of every climber in a block is too expensive to attempt.

Where damage from wild animals is experienced, it may be necessary to modify the above operations. So far little damage from elephants or other game has been experienced on Kilimanjaro.

With the indifferent supervision and inferior labour available on Kilimanjaro, the cost of subsidiary silvicultural operations in camphor forest is about ten men days an acre. With better supervision, costs might fall, but equally they will rise where many large useless trees have to be felled or girdled.

The methods described have been strikingly successful in the Kilimanjaro camphor forests, where there are now several hundreds of acres of flourishing young crops which would compare well with naturally regenerated forest crops in countries where forestry has been practised for far longer than in Tanganyika.

Unfortunately the reasonably rosy picture that it is possible to paint concerning camphor does not apply to other valuable species in the Kilimanjaro region, e.g. podo (*Podocarpus*) and lolyondo (*Steganthus*) in the mountain forests, and mvule in the lowland forests. A certain amount of regeneration of *Podocarpus gracilior* and *P. milanjianus* is scattered through parts of the mountain forests but nowhere is it prolific. Neither species responds to coppicing and all that can be done at present to assist the young trees is to free them from climbers and other competitors, and reduce overhead shade to a limited extent to stimulate growth. Both species appear to be shade-loving so that this reduction of overhead shade must be done with the greatest care.

Cedar regeneration occurs in places, particularly where there has been a fire. Wherever it is found, it too should be helped by cleaning and climber-cutting. Young plants of various other species, particularly mhaa, milimangombe and pillarwood (*Cassipourea*) are scattered throughout the forests, and regeneration of these and other secondary timbers should be assisted during cultural operations, provided that their growth will not interfere with that of more valuable timbers.

The position regarding the natural regeneration of lolyondo is puzzling. In many areas there is hardly any established natural regeneration to be seen although in places, and at certain seasons, the ground is carpeted with young seedlings, which later disappear. There is often a thick layer of rather dry humus in the lolyondon forests, and it is possible that the young seedlings dry out in this. Reduction of the layer by controlled burning might be a possible remedy, but if it was likely to be a success I would have expected to see lolyondo regeneration establishing itself after accidental fires, which does not appear to be the case. The subject needs thorough study by a silviculturist. Regeneration of olmasi (*Olea hochstetteri*) is known to be abundant in some areas but sparse in others; the brown olive or senefu (*O. chrysophylla*) regenerates well and possesses strong coppicing powers.

NOTE BY A. L. GRIFFITH, SILVICULTURIST, E.A. AGRICULTURE AND FORESTRY RESEARCH ORGANIZATION

Experimental work on the lines advocated by Mr. Champion has been done in Uganda in the last year. These experiments were intended to determine whether such operations as climber cutting and under-storey weeding in natural forest were practicable and economical. Results in Budongo forest so far show that both operations, whether separate or combined, are practical. Climber cutting costs about two to three man days per acre, while climber cutting combined with under-storey weeding costs some four to five man days per acre. It is too early yet to estimate what the effect of these operations is on regeneration that is present, or on inducing regeneration where it is absent. Experiments on felling, poisoning and girdling leafy useless under-storey species are in progress.

Present indications in Uganda are that such "improvement operations" are practical and probably economical, particularly if they can be combined with other operations such as enumeration or regeneration assessment. The main item of cost is that of line cutting to delimit the areas treated. This cost is the same however many operations are carried out in the area delimited.

II INTERNATIONAL CONGRESS OF PHYSIOLOGY AND PATHOLOGY

Copenhagen, Denmark, 7th to 10th July, 1952

The International Standing Committee, appointed at the Milan Congress in 1948, having examined the possibilities for holding the next Congress, it has been agreed that the II International Congress of Physiology and Pathology of Animal Reproduction and of Artificial Insemination will be held in Copenhagen, Denmark, from 7th to 10th July, 1952, with the following programme:—

(1) The physiology of reproduction.

(2) The pathology of reproduction.

(3) Artificial Insemination (A.I.) of domestic animals.

The Standing Committee has nominated Dr. John Hammond, School of Agriculture, Cambridge ,as president, Professor Nils Lagerlöf, Stockholm, as vice-president, and Professor Ed. Sorensen, Copenhagen, as secretary-general.

The Congress is sponsored by the Danish Ministry of Agriculture and will be organized by The Royal Veterinary and Agricultural College, Copenhagen, the Danish Federation of Cattle Breeding Societies for A.I., and the Society of Danish Veterinary Surgeons.

A more detailed, tentative programme will be issued as soon as possible. All particulars are obtainable from the Secretary-General, Professor Ed. Sorensen, The Royal Veterinary and Agricultural College, Bülowsvej 13, Copenhagen. V. Denmark.

PLUM VARIETY TRIALS AT THE HORTICULTURAL STATION, MOLO, KENYA

By T. H. Jackson and Barbara E. Roger, Dept. of Agriculture, Kenya

(*Received for publication on 5th April,* 1951)

Observational trials on 28 Japanese plum varieties and 2 varieties of prune are in progress at Molo. The variety trials are combined with trials of certain varieties on different rootstocks, and on their own roots. The first trees were planted at Molo in July, 1946, and are now beginning to bear fruit, but they are not yet of course, in full bearing; additional varieties have been planted each year since. Although it is only four and a half years since the oldest trees were planted it has been possible in this time to make many observations on growth, cropping, reaction to climate, rootstock influence, etc. This report aims at presenting some of the information gained to date; it must be emphasized, however, that it is only a progress report and later results may necessitate modification of some of the conclusions reached.

The following is a list of plum varieties under trial together with notes on their performance:—

Abundance, planted 1950; no observations to date.

Apple, planted 1950; no observations to date.

Apricot, planted 1946; a small, early, yellow plum which makes excellent jam. Started bearing at 2½ years from planting. Average crop per tree at 4½ years from planting—64 lb. Cropping season 29th December to 2nd February. Susceptible to attack by Fruit Piercing Moth. Resistant to prolonged dormancy. Recommended for planting from 6,500 ft. upwards.

Beauty, planted 1946; an early red dessert variety of similar flavour to Santa Rosa; the size of fruit varies from small to very large; as the skin is very thin it requires careful packing for market. Started bearing at 3½ years from planting. Average crop per tree at 4½ years from planting—21 lb. Cropping season 2nd January to 24th January. Susceptible to prolonged dormancy. Recommended for planting from 8,000 ft. upwards.

Beckie Smith, planted 1947; a late red dessert variety of good quality. Started bearing at 3½ years from planting. Crop not yet recorded. Cropping season starts mid-February. Fairly susceptible to prolonged dormancy. Recommended for planting from 8,000 ft. upwards.

Burbank, planted 1950; no observations to date.

Cape Yellow Gage, planted 1950; no observations to date.

Chalcot, planted 1950; no observations to date.

D'Ogen Prune, planted 1947. Not in bearing. Very susceptible to prolonged dormancy. Not recommended.

Duarte, planted 1947; a mid-season to late red dessert variety, size of fruit varies from medium to large. Started bearing at 2½ years from planting. Crop not yet recorded. Cropping season starts end of January. Fruit subject to physiological cracking. Susceptible to prolonged dormancy. Not recommended at present.

Eldorado, planted 1950; no observations to date.

Eclipse, planted 1950; no observations to date.

Formosa, planted 1950; no observations to date.

Gavioa, planted 1950, no observations to date.

Hale, planted 1947; a mid-season to late variety with greenish yellow fruit sometimes having a pink cheek, size medium. Probably the most vigorous of the Japanese plums, but the fruit is not of high quality. Started bearing at 3½ years from planting. Crop not yet recorded. Cropping season starts 5th February. Fairly resistant to prolonged dormancy. Recommended for planting from 7,000 ft. upwards.

Jardine's Early, planted 1946; a mid-season variety of great vigour, the fruit is pinkish red and of medium size. Started bearing at 3½ years. Average crop per tree at 4½ years from planting—77 lb. Cropping season 12th January to 2nd February. Resistant to prolonged dormancy. Very easily propagated from stem cuttings. Recommended for planting from 6,500 ft. upwards.

Methley, planted 1946; probably the most popular early variety, the fruit is deep purple and of medium to small size. The trees have a marked tendency to overbear, and are not very vigorous, this often results in the fruit being of very small size. This variety is popular on the fresh market, for canning and for jam making. Started bearing at 2½ years from planting. Average crop per tree at 4½ years from planting—49 lb. Cropping season 29th December to 23rd January. Trees grown on their own roots are considerably more vigorous, and come into bearing only slightly later than those on rootstocks; it is recommended that this variety should be grown on its own roots. Methley is resistant to prolonged dormancy. Recommended for planting from 6,500 ft. upwards.

October Purple, planted 1946; the best and latest dessert variety, the fruit is large and purple. The fruit does not always mature properly at altitudes of around 9,000 ft. Started bearing at 4½ years from planting. Crop not yet recorded. Cropping season starts in March. Rather susceptible to prolonged dormancy. Recommended for planting from 8,000 ft. upwards.

Purple King, planted 1946; a late variety, the fruit is red and appears rather similar to Satsuma. Started bearing at 3½ years from planting. Crop not yet recorded. Cropping season starts 29th January. Susceptible to prolonged dormancy. Not recommended at present.

Santa Rosa, planted 1946; a popular mid-season dessert variety, the fruit is purple, of medium to large size and has a high flavour. At the Molo Station, Santa Rosa has set very poor crops so far, the average yield per tree at 4½ years from planting was only 1 lb. It is reported to bear well in the Limuru area. Old trees in a private orchard distant only one mile from the experiment orchard, set quite good crops of fruit. Fairly resistant to prolonged dormancy. Further results must be awaited before this variety can be recommended.

Late Santa Rosa, planted 1950; no observations to date.

Satsuma, planted 1947; a late canning or bottling variety, the fruit is reddish purple, hard and of medium size. Started bearing at 3½ years from planting. Crop not yet recorded. Cropping season starts about mid-February. Susceptible to prolonged dormancy. Recommended for planting from 8,000 ft. upwards.

Settler, planted 1946. The fruit of this variety is indistinguishable from Methley but the trees are much more vigorous and have carried a heavier crop at 4½ years from planting than Methley; the cropping season is slightly earlier. Started bearing at 3½ years from planting. Average crop per tree at 4½ years from planting—71 lb. Cropping season 16th December to 23rd January. Resistant to prolonged dormancy. Trees on their own roots are recommended. It would appear from results to date that Settler is a better variety to plant than Methley. Recommended for planting from 6,500 ft. upwards.

Shiro, planted 1946, a mid-season dessert plum, the fruit is yellow, of large to medium size. Started bearing at 3½ years from planting. Average crop per tree at 4½ years from planting—41 lb. Cropping season 10th January to 10th February. Susceptible to attack by Fruit Piercing Moth. Fairly susceptible to prolonged dormancy. Recommended for planting from 8,000 ft. upwards.

Sugar Prune, planted 1947. Not in bearing. Very susceptible to prolonged dormancy. Not recommended.

Tazagine, planted 1946. The fruit of this variety is indistinguishable from Methley, but the trees tend to be more vigorous. Started bearing 2½ years from planting. Average crop per tree at 4½ years from planting—56 lb. Cropping season 29th December to 29th January. Resistant to prolonged dormancy. Trees on their own roots have done exceptionally well. It is probable that Tazagine is a better variety to plant than Methley. Recommended for planting from 6,500 ft. upwards.

Watson's Cropper, planted 1947. Started bearing at 3½ years from planting. Crop not yet recorded. Cropping season starts 2nd February. Susceptible to prolonged dormancy. Not recommended at present.

Wickson, planted 1947. A dessert plum of high quality; fruit large to medium, yellow with red cheek or all red. Started bearing at 2½ years from planting. Crop not yet recorded. The fruit is subject to physiological cracking. Susceptible to prolonged dormancy. Not recommended at present.

Wilson, planted 1946. An early to mid-season variety, size of fruit medium to small, yellow with red cheek, of most attractive appearance. Started bearing 3½ years from planting. Average crop per tree at 4½ years from planting—49 lb.

Cropping season, 10th January to 2nd February. Resistant to prolonged dormancy. Recommended for planting from 6,500 ft. upwards.

Choice of Varieties

It is natural when deciding which varieties to plant to choose early, mid-season and late varieties in order to extend the season as much as possible. Late varieties also are generally easier to market than early or mid-season ones. It should be remembered, however, that late varieties are more difficult to produce. The fruit remains on the trees for a considerably longer period which means that fruit losses are higher. In February and March when most of the late varieties are harvested there are high winds and the fruit is apt to be blown from the trees. At this time of the year the birds are very troublesome as there is little else for them to eat. At Molo in the 1949-50 season late varieties did not ripen satisfactorily, the fruit coloured well but remained hard and sour and was inedible except when stewed. It is thought that this condition of the fruit was caused by drought conditions at ripening time; if this proves to be the case the planting of late plum varieties will be restricted to high rainfall areas, and irrigated orchards.

Most of the plum varieties grown in Kenya are classed as self-unfruitful, this means that cross-pollination with another variety is essential if good crops are to be produced. For adequate cross-pollination it is advisable to plant not less than three plum varieties in any orchard. Varieties which are classed as self-fruitful are Methley, Tazagine and Santa Rosa, but even with these, better crops are likely to result when another variety is planted for cross-pollination.

Growing Plum Trees on their Own Roots

The above report contains a recommendation that certain varieties should be grown on their own roots; it is hoped that a few notes on this subject will be of use to growers in producing their own trees.

The following simple method is used at the Molo Station:—

The trees receive their annual pruning in August. Shoots made during the previous growing season are selected from the prunings and cut into lengths of approximately 9 in. The soft tips of the shoots are not used for cuttings. The prepared cuttings are treated with a proprietary growth substance which will assist rooting but this is not essential. The cuttings are planted in a nursery bed, in ordinary soil, at a spacing of 6×12 in. About two-thirds of the cutting should be immersed in the soil which must be made very firm round the cutting. The cutting bed is shaded by sticking in short leafy branches between the cuttings; the shade is removed after about 4 weeks. In dry weather the bed should be thoroughly watered about once a week. Cuttings which root successfully will generally be ready for planting out in the field during the following July.

KENANA CATTLE AT THE GEZIRA RESEARCH FARM

By M. C. Hattersley, Manager, Gezira Research Farm, Wad Medani, Sudan

(*Received for publication on 28th February*, 1951)

The increasing interest taken in the Gezira Research Farm herd of Kenana cattle by many distinguished visitors makes it appear desirable that some notes on the source and general establishment of the herd should be placed on record.

The name "Kenana" is taken from the semi-nomadic tribe which, under natural conditions in the Sudan, owns the major herds of this type of animal. The type is indigenous and appears to have descended from the Zebu cattle said to have emigrated from Asia about 500-100 A.D. The little selective breeding done at Wad Medani during the past few years suggests that a pure type of short-horned Zebu is emerging. Comparisons of mature and calf body weights, late maturation, shape of head, dewlap and hump, all suggests that although different in colour they very closely resemble the Sahiwal and Sindhi cattle of India which, judged from illustrations, are also of semi-polled character.

Their natural distribution in the Sudan lies approximately between lat. 10°–13° 30″ N. and long. 32° 30″–34° E. in a rough triangle bounded by Sennar, Singa, Roseires and Kosti. This area, known as the Fung, consists of Acacia scrubland with an average rainfall of 18 in. in the north to 32 in. in the south.

It is not possible to draw full comparisons between the animal in the natural surroundings and as it is to-day at the Farm, insufficient data being available from its rural home, where, however, it can be said to show the general characteristics of the short-horned Zebu type.

Origin of Present Herd.

Different types of indigenous cattle have been kept on the Research Farm since about 1921, and at first attempts were made to cross local stock with imported animals; this policy was abandoned for various reasons and foundation cows of the Kenana type were introduced as being the most suited to requirements. It was not, however, until 1937 that serious culling and recording was adopted. From 1925 to 1948 some 270 mixed cattle have been recorded as having passed through the Farm, and experience with these has confirmed that the Kenana type is probably the most suitable for local conditions. From the period prior to 1937 only one cow remains in the herd book; she is Ataminu and can be regarded as the real founder of the herd. born in 1930, she calved every year from 1933 to 1948 inclusively, and the present stud bull Atebrin was bred from her. In the period 1939-40 military demands for liquid milk necessitated the purchase of upwards of 100 cows from the Kenana tribe, and of these the best 20 were kept and mated with Atebrin; from this breeding and selection the present herd became established and now consists of six families, A, C, E, F, J, O, named after foundation cows Ataminu, Cosmea, Emira, Ferusa, Jasmina and Om Rish. The original bulls used with the foundation cows were the best of the Kenana type that could be found and only three bulls were used to any extent before Atebrin came into general use in 1942. Atebrin is now 11 years of age, still active and virile, with 45 male and 46 female calves to his credit. Twenty-five of these females from the above six families are now in the herd. Some little inbreeding has been done, but one or two young bulls of known pedigree are now in use with Atebrin's female progeny; one Cyprus (dam Cosmea), borne 1943, contains no "A family" blood. Culling has been severe and animals not reaching the required standard of milk production or failing to conform to type are disposed of immediately.

Policy.

Originally the cattle were associated with the experimental work of the Farm but were divorced from this, except as tillage animals, in 1945, when it was decided to be impossible to simulate rural grazing habits of half-starved cattle by means of improved and well-fed animals. It is true that the Gezira Research Farm cattle are being fed as a Gezira tenant could feed his cattle if he would; nevertheless, at the Farm they never live under conditions of semi-starvation, which is the rule for much of the year in the Gezira scheme.

An extract from a discussion on "Cattle in the Tropics" between Dr. S. W. Das Gupta,

Councillor of Agricultural Science, U.N.E.S.C.O., Dr. Norman G. Wright, London, and Dr. John Smith, Veterinary Adviser to the Colonial Office, is as follows:—

> "In undeveloped countries, where cattle are used for agriculture, one should consider the rural areas more than the urban areas and keep in mind all these purposes for which cattle are used, viz. milk, beef, and working capacity should never be sacrificed for the other two."

The policy governing the management of the herd, therefore, is a dual purpose one, the object being to produce a female with reasonable milk production and a male suitable for tillage purposes. Stress is laid upon the necessity for both these types producing results on the type of foodstuff available to the native tenants in the Gezira scheme.

Beef production has not been seriously considered in connexion with the herd, and the Sudanese prefer to eat mutton rather than beef. It is, however, worth noting that a beefy subtype of animal, both male and female, does occur among the Kenana cattle, which should not be overlooked when a wider policy is adopted. It is possible, however, that the policy may be modified towards increased milk production as mechanization and village educational welfare schemes develop; and if it becomes possible to secure better conditions for native-owned animals.

Feeding and Management.

As emphasized above the feeding of the herd is such as to conform with that which a Gezira tenant could give his cattle if he conserved his resources. The Gezira scheme itself lies within a large flat fertile plain between the Blue and White Niles, and consists of an irrigated area split up into some 22,000 tenancies (1946-47). Each tenant normally crops 10 acres of cotton, five acres of dura (*Sorghum vulgare*), up to five acres of lubia (*Dolichos lablab*), and has 20 acres fallow to complete a 40-acre holding. His main animal feeding stuffs consist of rainy season weeds, dura grain, dura stalk (*gassab*), dura stubble, green or baled lubia, and cotton crop remains.

There is an average rainfall of 15 in. per annum which falls mainly in July and August, with about 2 in. in September.

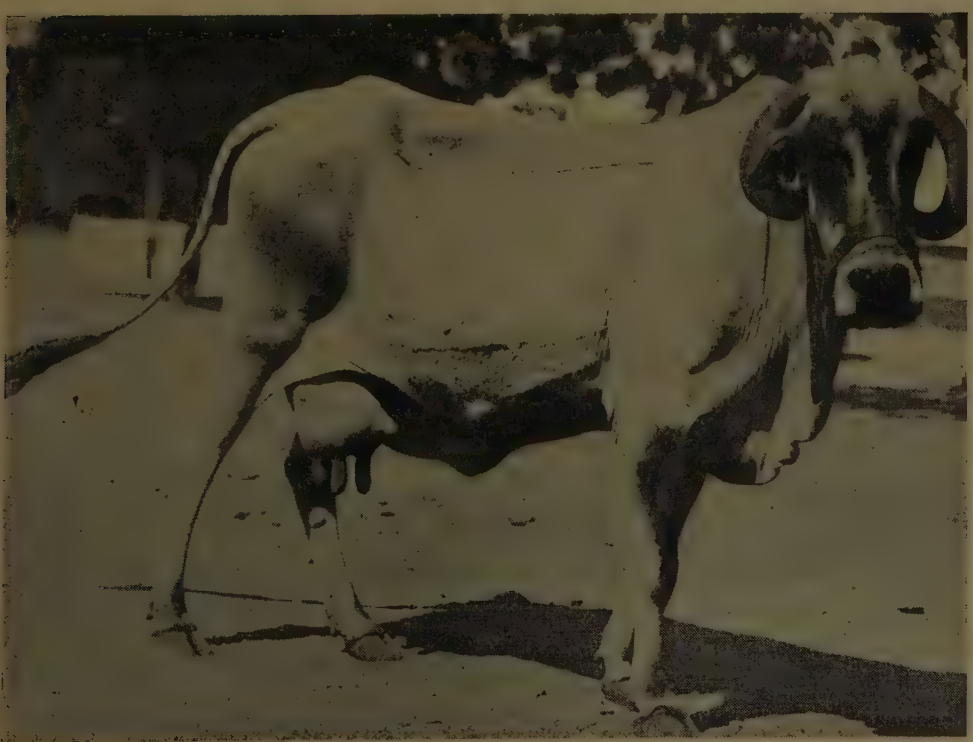
Availability of feeding stuffs for different periods of the year can be classified as follows:—

Natural Resources	*Conserved Resources (from previous season)*
August, September, October	
Rain weeds, the quantity of which varies greatly from season to season, usually grazed off hard by the end of September.	Grain. Stacked gassab. Baled lubia.
November, December, January	
Fresh lubia grazing available by the end of December but frequently hired out to nomadic sheep owners. From mid-December onwards grain, gassab, stubble abundant.	Grain. Stacked gassab. Baled lubia.
February, March, April	
Dura stubble is grazed off bare by the end of February, some fugitive lubia grazing is available from secondary growth (watering of the crop ceases in January). Grazing off the remains of the cotton crop commences in April.	Grain. Stacked gassab. Baled lubia.
May, June, July	
No lubia grazing available. No cotton available after end of May. No rain weeds can be expected before August.	Grain. Stacked gassab Baled lubia.

From the above it is obvious that a tenant can always have conserved resources. If on the other hand he takes advantage of the ready cash market for his grain, gassab and lubia crop, his cattle will suffer accordingly. At the Gezira Research Farm the cattle are fed only on the above foodstuffs with the exception of a little cotton seed cake which should be available to the tenant. Stacked gassab and baled lubia are used to the fullest extent. At the Farm an area of 1,000 feddans (1,040 acres) supports approximately 100 cattle, 150 sheep and other stock; a tenant with a 40-acre holding should be able, therefore, to maintain a few cattle well.

KENANA CATTLE AT THE GEZIRA RESEARCH FARM

JASMINA



OM RISH

KENANA CATTLE AT THE GEZIRA RESEARCH FARM—(*Contd.*)

ATEBRIN

ATAMINU

Calves are fed by bucket from the first day and consume approximately 70 gallons of whole milk in the first three months, after which they only receive occasional drinks of skimmed milk. They receive a little crushed grain up to 9 months of age, but after this no more is given until they either calve down or commence work as tillage animals. When not in harness the animals spend the day grazing off crop remains, rain weeds, stubble, etc; with a little fresh lubia grazing during the winter months. They are penned at night.

Hardiness.

The cattle are treated against rinderpest, bovine pleuro-pneumonia, hæmorrhagic septicæmia and anthrax, the last two annually. Lactation records are not infrequently upset by disease, but although in the last five years all the above diseases have been met with, plus foot and mouth disease, the herd maintains its strength, recoveries are rapid, and very few fatalities occur. Mastitis and abortion are comparatively rare.

There is little to indicate any loss of hardiness and in this connexion it is noted that the tillage animals have remained healthy throughout, with the exception of one or two cases of hoven.

At the end of November, 1950, the herd consisted of:—

Females: Original foundation cows 3; home bred cows 20; home bred heifers 6 (3 years old); home bred heifers 7 (2 years old); home bred heifers 8 (1 year old); 1950 female calves 7.

Males: Stud bulls 3; under observation as possible stud animals 5; for tillage animals or distribution 6; under 2 years old 20.

Type.

Female.—Females tend towards the dairy conformation but to date only one or two animals show the wedge-shape body of a true dairy animal. Heifers are late in maturing, not being large enough for service, usually, before 2½ years of age. Earlier serving appears to hinder the subsequent growth of the animal, but in this connexion it should be noted that no experimental work has been attempted with regard to breeding from male or female stock at an earlier age.

Colour is white to steel grey, shading to dark on shoulders, neck, cheeks and front legs, changing to lighter or darker seasonally; hair short; tail white; switch usually black: There is a slight hump and prominent dewlap. Head is variable with long face to very broad muzzle. Horns are loose, gradually disappearing from the breed or remaining as short stumps. Calves are all born red-brown, changing to grey at 3-4 months of age.

	At birth	*Heifer 2 years*	*Mature cow*
Average weight (lb.)	49	600	900
Average height in cm. hoof to back	70	120	132

After conformation to type and compliance with the standards of feeding and management given above, the standard demanded from a female is that she calves down regularly every 12 months and produces a minimum of 300 gallons of milk per lactation.

A few selected data below indicate the regularity of the calvings.

Number of Months between Calvings

Home Bred Cows

Calf No.	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Cow No. 1	–	9	10	11	12	15	11	11
Cow No. 2	–	11	9	11	11	12	13	—
Cow No. 3	–	12	13	11	11	11	11	11
Cow No. 4	–	11	13	13	11	13	10	11

Cows from Fung

Cow No. 1	–	14	11	18	11	10	11	10
Cow No. 2	–	12	12	13	14	14	—	—
Cow No. 3	–	11	11	16	13	12	11	12
Cow No. 4	–	13	13	10	13	10	10	11

Also from a total of 120 periods between calves from all cows the average is 368 days.

Male.—Colour is as for females but tending to be darker generally. Hump and dewlap more prominent than in the female. Head and face typically male. Horns are larger than in females, but loose and gradually disappearing from the breed. Mature animals in working condition average 1,100 lb. weight but may attain 1,200-1,300 lb. Usually bulls are not put to stud before 3-3½ years of age; experience has shown some of them to be potent before this, but the majority are not usually large enough for mature cows; and are frequently disinterested, or nervous.

After conformation to type the main points sought for in a good tillage animal are stamina and good temperament; the average size of 1,100 lb. is preferred; good feet are essential as lameness and sluggishness can be attributed to too rapid or irregular growth of hooves.

Although wary of strangers, wildness occurs in very few of the animals and any showing such are eliminated. Docility, even if an acquired characteristic, appears to be permanent; a well-trained animal rarely gives trouble and a good ploughman can work his team by voice control. A normal days' work of 5 hours with a ridging plough covers a walking distance of 9-10 miles; the animals then rest and graze. If well fed they can keep this up day after day, even in extreme heat, and an afternoon shift of 2-3 hours can, if necessary, be demanded of them. Other duties consist of haulage, cultivations by horse hoes, Cambridge roller, and ploughing. Animals commence light training at 3 years of age when they are put on to full working rations; at 3½ years of age they are fully trained tillage animals and should give 10-15 years satisfactory service. Gezira Research Farm keeps a team of 25 trained tillage animals, and their work is most usefull on the many experimental sub-plots necessitated by statistical layouts.

Many of the young animals, particularly males, are sent out to Government Schemes and Gezira Tenants' Clubs, and since 1940 some 150 improved animals have been distributed to various parts of the Sudan. They are in demand for all areas, and animals exported to Kenya and Tripolitania have received good reports.

Milk.

No special emphasis has been placed on management, feeding, or selection for maximum milk production; efforts have been directed only to maintaining the minimum of 300 gallons with the standard of feeding mentioned previously.

Up to the end of 1948 cows in milk received 8 lb. of concentrates per day irrespective of yield; this usually consisted of a mixture of cotton or sesame oil cake and millet grain (dura). During 1949 the system was changed and cows in milk were fed on a production basis, but the total amounts of concentrates allowed during a lactation exceeded by very little any previous issues. The value of fresh green fodder cannot be over-emphasized in connexion with milk production.

The butter fat content of the milk averages 5 per cent for the herd, and reaches up to 7 per cent for individual cows.

Average yield figures are given below for four 4-year periods, and 1949 and 1950 yields from home bred animals only, are given separately. A gradual improvement is indicated.

Period	No. of Lactations Recorded	Average lb. per Lactation	Average No. of days per Lactation
1937/40	35	2,192	196
1941/44	94	2,198	222
1945/48	63	3,627	242
1949*	11	3,800	261
1950*	11	4,494	255

Analysing into groups the following table emerges:—

Period	No. of Lactations	Over 1,000 lb. Under 2,000 lb.	2,000 lb. 3,000 lb.	3,000 lb. 4,000 lb.	4,000 lb. 5,000 lb.	5,000 lb.
1937/40	35	16	12	4	3	
1941/44	94	10	26	43	12	3†
1945/48	63	4	12	24	20	3†
1949*	11	—	—	7	4	3 { Home bred
1950*	11	—	1	2	5	

* All completed lactations from females in herd book.
† High yields by one or two foundation cows.

In considering the high yields obtained by three of the foundation cows it should be noted that they are the best of a large number of animals. They also illustrate the value of the indigenous material available for large-scale selection in the country.

Of the present stud bull Atebrin's females, only four have so far given their heifer lactations, three of which have also completed the second lactation.

It takes about nine years to prove a bull owing to the late maturity of the animals, so the original choice of Atebrin was fortunate. In conformation his progeny are good, and an indication of his milk potentialities is shown below.

Considering that heifer yields do not always indicate the future potentialities of the cows and also the figures for the second lactation, the above comparison is considered satisfactory and in Atebrin's favour.

Examination of the actual lactation period, with an average of 242 days for 1945-48, shows that over 65 per cent of the milk is produced during the first five months of the period, which by modern criteria is good; it shortens the period of heavy concentrate feeding, tends to give the cows more rest between calves, and is economical in labour.

The milk production possibilities within the breed are indicated by Boyns (1947) who succeeded in obtaining a lactation figure of 10,272 lb. over 339 days from a Kenana type cow. Hewison (1945) gives a considerable number of records for other Zebu cattle in the Northern Sudan.

Future increase in the average milk production in the Kenana herd at the Research Farm, under the terms for management and feeding above mentioned, would appear to be more suitably obtained by the selection of a dairy-type body, together with the use of a proven sire rather than by more skilled management and heavier feeding. But it must be emphasized that no serious selection for dairy types alone has been carried out.

Much of the work summarized in the foregoing has been carried out by Mr. J. W. Hewison, Mr. E. R. John, and Mr. W. A. Porter of the Sudan Government, Ministry of Agriculture. The author took over the management of the herd in 1944 and has used data from many earlier records, which are acknowledged.

BIBLIOGRAPHY

Bennett, S. C. J., John, E. R., and Hewison, J. W. (1948). Animal Husbandry. In Agriculture in the Sudan, edited by J. D. Tothill, pp. 633-667.

Boyns, B. M. (1947). Sudanese Cattle as Milk Producers. Emp. J. Exp. Agric., 15, pp. 27-41.

Hewison, J. W. (1945). Dairy Farming in the Northern Sudan. E. Afr. Agric. J., 11, p. 104.

Joseph, A. F., and Martin, F. J. (1922). The Composition of Cows' Milk in the Sudan. The Analyst, 47, pp. 426-629.

Scott, J. R. (1947). Kinana Cattle. Sudan Notes and Rec., 28, pp. 181-183.

Walley, V. P. (1936). Working Cattle in the Anglo-Egyptian Sudan. Emp. Cott. Gr. Rev., 13, pp. 294-296.

Yields from Four Atebrin Females Compared with Dams

	Dam Yields (Foundation Cows)				Corresponding Daughters			
	Average		Highest		Heifer Yield		2nd Lactation	
	lb.	Days	lb.	Days	lb.	Days	lb.	Days
1.	3,863	249	4,218	250	4,769	340	6,426	283
2.	3,476	263	4,900	350	3,261	219	3,849	183
3.	4,830	282	7,269	355	3,392	293	3,815	273
4.	3,935	253	5,026	244	3,757	238	—	—
			Average for heifers..		3,795	272	—	—
			1945/48 average for herd		3,627	242		

NOTES ON SOME CONIFER NURSERIES IN THE SOUTH AND WEST OF THE U.S.A.

By A. L. Griffith, E. A. Agriculture and Forestry Research Organization

(*Received for publication on 2nd May, 1951*)

These notes were made on a tour of the U.S.A. in September to November, 1950. The tour was E.C.A. project O.E.E.C. 18/B Group 4, Tropical Forestry.

Grateful acknowledgment is made to the U.S.A. for providing the dollars to make this interesting and instructive tour possible, and to the U.S. Forest Service and Soil Conservation Service, for their hospitality, arrangements and helpful information so freely given.

The study of conifer nurseries is of great interest to the tropics in general, and to East Africa in particular, as soft woods are being raised on a large scale. These soft woods are all exotic to East Africa, and consist chiefly of pines and cypresses which come from the southern states of the U.S.A. and Mexico.

Description of Localities.

Nurseries were seen at Monument near Colorada Springs (Colorado), Henniger Flats near Los Angeles (California), Olustee near Lake City (Florida). In addition, we were given details of nursery work for planting at Calhoun (S. Carolina) and Copper Basin (Tennessee).

Monument.—Conditions here are comparatively easy. The elevation is about 1,500 ft. and the rainfall 15 in., varying from 10 in. to 25 in. but fairly well distributed over the year; 50 per cent of the rain, however, comes in May to August. Temperatures vary from about 90° F. to 100° F. in the summer, and to 17° F. to 20° F. in the winter. There is little snow in the low country, but it is general in the higher country from October to April.

Henniger Flats.—Conditions are comparatively difficult. The elevation is 2,600 ft. and the rainfall 25 in., but with a great variation of 7 in. to 40 in. in the past 50 years. The general rainy season is November to May, and sudden heavy storms are the rule. The soil is a poor decomposed granite, and very long dry seasons occur. Temperatures vary from about 100° F. in the summer to about 25° F. in the winter.

Olustee.—Conditions are comparatively easy. The elevation is 200 ft. and the rainfall 53 in. This rainfall averages from 6.5 in. per month in the wet season (1st July to 30th September) to 3.3 in. per month in the dry season (1st October to 30th June). The average maximum monthly temperature is 80° F. and the average minimum monthly temperature is 58° F., but extremes have been as high as 106° F. and as low as 6° F. It is the rule for occasional frosts to occur in the winter. On an average there are 14 frosty nights in the year.

Ocala.—Here conditions are still comparatively easy, but slightly more difficult than Olustee. The elevation is 85 ft. and the rainfall 53 in. This rainfall averages 7.5 in. per month in the wet season (July to September) and only 3 in. per month during the rest of the year. The average maximum monthly temperature is 81° F., and the average minimum monthly temperature is 59° F., while extremes have been 102° F. and 12° F. Frosty nights average ten per year.

Both Olustee and Ocala are towards the middle of the northern part of the Florida peninsula, and relative humidity is high. The average relative humidity recorded at Jacksonville (Florida) at 6 a.m. is 83 per cent, at noon 61 per cent, and at 8 p.m. 76 per cent.

Methods Used.

Monument.—Here all operations are mechanical, and the nursery which produces 1½ million plants a year on 4½ acres is run by three men only. For about one month, extra hands up to about 20 are taken on. Seed extraction is mechanical, as also are the operations of bed preparation, seed sowing, weeding, transplanting, lifting and watering. The reason for all this mechanization of the nursery work, is that labour is expensive ($1.25 per man hour) and it has been found that sufficient success can be obtained by mechanical means.

Soil fertility is maintained by sowing peas and oats, and by the use of pine mulch and chemical fertilizers. There is, however, no regular rotation, nor do they feel the need for one. Plants are planted out as 3+0 seedlings, or as 2+1 year transplants. The watering is done through holes in oscillating pipes at about 3 ft. from the ground. This is called the "Skinner" watering system. Its disadvantage is that dirty water tends to clog the oscillators. The species are *Pinus ponderosa* and *Picea englemanii* almost exclusively.

Henniger Flats.—Here all operations are done by hand, and there is no mechanization at all. Even watering is done by hand. This is because conditions are difficult, and it has been found that any mechanization leads to a low percentage of success. The work is expensive and the average cost per plant is about 50 cents. It is particularly to be noted that experience shows that success in these difficult conditions is dependent on great attention to detail in all operations. Plants are put as 1+1 or 1+2 year transplants in tar paper containers 12 in. × 3 in. × 3 in. Considerable culling is done. This often amounts to as much as 50 per cent of the plants, but it is found to be worth while every time.

The main species used is *Pinus coulterii* of which they produce about 100,000 plants a year. Other species used are *P. attenuata, P. sabiniana, Cupressus virginiana, Libocedrus decurrens, Pseudosuga macrocarpa, Pinus halepensis, P. radiata,* a variety of eucalypts *Ailanthus glandulosa,* and *Robinia pseudo-acacia.* The nursery has been in use for 27 years, and fertility is kept up by bringing in new soil every few years, and by planting vetch and digging it in after a few months.

Olustee.—Here again all operations are mechanical. The nursery is 168 acres in extent, and raises annually about 10,000,000 plants. It is run by six men of whom three are permanent, and skilled in vehicle and machine maintenance, while three are unskilled casual labour. For about one month this number is raised to 40, but a great deal of the labour is by coloured women paid at 40 cents per hour. Plants are about 10 months in the seed bed, and are then planted out direct as 1+0 year seedlings. This is because firstly, the species (Slash pine *P. caribœa*) does not like to be transplated, and secondly, it has been found unnecessary.

Seed extraction is mechanical after about 75 to 90 days drying of the cones. There is no selection of the mother trees, but selection of areas and some sorting of the cones is done. After drying, the cones go through a "rattler" which shakes out the seed, and then to a "dewinger" which removes the wings by brushes, and a "separator" which winnows the broken wings. The empty cones are used as fuel. One bushel of cones gives 1 lb. of seed (about 14,000 seeds) and this results in about 10,000 plants.

Bed preparation, sowing, weeding, lifting and watering are all done mechanically. Watering is by overhead sprinklers of the Thompson type, and are not liable to clogging by dirty water. Culling of the plants is done by a conveyor belt, and the usual throw-out is about 25 to 30 per cent of the plants.

Samples of the seed are taken as soon as it is extracted, and germination tests reproducing seed bed conditions are made. The actual sowing is in lines 8 in. apart, and the seed density is about 20 per linear foot of the line. The seed is sown on the surface, and is covered by hand with pine mulch. The nursery rotation is three years; one year seedlings, and two years cover crops. Weeding is done by a chemical spray, (the machine is rather like a seed drill) and 8 to 12 applications per year of 15 gallons per acre of mineral spirits are made. Once a month, bordeaux mixture is sprayed to stop disease.

The cost is $2.25 per 1,000 plants, $2.85 per 1,000 plants wired, bundled, and loaded on a truck. The species is slash pine (*P. caribœa*) exclusively.

Ocala.—Here the difficulty in the conditions is due to the species, sand pine *P. clausa* rather than to the locality. The work is of a nursery type, and under nursery conditions, but is experimental in character, and is intended to find out the conditions necessary for the successful natural regeneration of the species for which they hope.

The difficulty is that normally the cones do not open on the tree unless the forest is burnt. Attempts to burn artifically have either been too light (when the cones did not open) or too heavy (when the seed was destroyed). Also, after a wild fire in some cases regeneration did not result.

The experimental work is randomized and replicated. The treatments used are:—

(*a*) Ants versus no ants (ants are killed by chlorodine powder or carbon bisulphide).
(*b*) Screening and no screening against rodents, squirrels and birds.
(*c*) Protection from heat by shading with gauze about 6 in. above the ground.
(*d*) Soil surface—
  (1) Bare mineral, soil (very sandy).
  (2) Litter of pine needles.
  (3) Litter of pine needles burned.
(*e*) Time of sowing—spring, summer, fall, winter.
(*f*) Depth of sowing. The seed is very small (50,000 to the lb. and about 1/16 in. diameter). Normal sowing would be at a depth of about 1/16 in. to ¼ in. but

experiments show that deeper sowing of about ½ in. to ¾ in. gives better results. The heat loss occurs by the heating of the radicle by the sun before the seedling is established (soil surface temperatures up to 160°F. have been recorded).

So far results indicate that protection from heat and protection against ants, rodents, birds and squirrels are essential, and without them no survival has yet been obtained.

Experiments have shown that seedlings will not wilt until the soil moisture content is below ½ of 1 per cent, so that in these nursery experiments there should be no less on this account, for even with a soil surface temperature of 160° F. this conditions was not reached.

Nursery for the Planting of Loblolly Pine, (P. tæda) in Calhoun Experimental Forest. This species for this area is raised in a big central nursery such as described for Lake City, Olustee. All operations are mechanical and the seedlings are planted out with a mechanical planter as 1+0 year old seedlings on old abandoned cotton fields. This mechanical planting gives 90 to 95 per cent success, and seedlings are about 2 ft. to 3 ft. high one year after planting out.

The elevation is 800 ft., and the rainfall 50 in. The soils originate from granite and schists, and give rise to red and yellow podsols by the leaching out of the minerals. The soil generally has been "mined" by cotton cultivation, and usually consists of 4 in. to 6 in. of plough soil with a heavy clay underneath.

Nursery for Planting in the Copper Basin.— This is at Clinton (Tenn.) 120 miles away from the planting area. The nursery area is 150 acres of which 90 acres are used for tree production. The rotation is one year seedlings and one year cover crop. The annual production is 12,500,000 plants, but the nursery capacity is 25,000,000 trees a year. All species are put out at 1+0 year seedlings. *Pinus strobus* is the only exception, and is used as 2+0 year seedlings. The main species grown are *P. rigida* (pitch pine) and *P. virginiana.* Other species raised are yellow poplar, black locust and red cedar. All operations are mechanical (as at Monument), and watering is done by overhead oscillating pipes.

The nursery staff is four permanent men of whom one is technical, and one does machine maintenance. Major repairs are done by a Tennessee Valley Authority garage unit. In rush times the temporary staff often goes to about 20 to 25 men, but never for more than about one month per year.

Mycorrhizal and Bacterial Soil Conditions.

In none of these nurseries are any precautions taken to ensure that suitable mycorrhizal and or bacterial conditions are present in the soil. In all of the areas there are many coniferous species, and although mycorrhiza and bacteria studies have been conducted by universities, precautions to see that suitable soil conditions are present are not considered necessary by the practical nurserymen. Apparently suitable conditions exist in almost any soil here. It is, however, very noticable that in the Pike's Peak (Colorado) plantations in burnt areas the plants suffered a very serious check for some 10 to 15 years. This was apparently due to soil conditions being affected by the fire, and might possibly be mycorrhizal in character. Similar conditions appeared to exist in the Copper Basin (Tennessee), but due to fume devegetation and extreme erosion as well as fire.

Application to Tropical Conditions.

The work seen in these areas may have great application in general in the tropics, and in East Africa in particular. Almost all the mechanical aids to nursery work *could* be used where labour is scarce or expensive. (In East Africa labour is often very scarce, but it is not expensive, being about $9 per month, as compared with $0.75 to $1.50 per hour in the U.S.A.)

Other lessons to be learned are: that in difficult conditions, speed, mechanization, cost and output *must* be sacrificed in order to obtain a high percentage of success (*vide* Henniger Flats); that in difficult conditions a lot of the difficulty may be due to characteristics of the species rather than to those of the site (Ocala as compared with Olustee); and that in difficult conditions intensive, well thought out, well laid out research may give results in a short time, and yet need not be elaborate or expensive (*vide* Ocala, where important indications have already been obtained in a year without an expensive laboratory or experiments of an elaborate or expensive nature).

Disease.

It was of interest to note in California that the cypress canker (*Monochætia*) is so bad on *Cupressus macrocarpa* that this species is regarded as a noxious weed, and is now almost impossible to obtain. No nurseryman stocks it. *C. arizonica, C. sempervirens* and *C. forbesii* are relatively unaffected by the canker. It was also noticed that (as in East Africa) hedges of *C. macrocarpa* kept low and well clipped do not appear to be affected by the disease.

COMPOST-MAKING IN THE FORT HALL DISTRICT OF KENYA

By G. P. Rimington, Department of Agriculture, Kenya

(*Received for publication on 7th April*, 1951)

The fertility of the land in the African reserves is steadily decreasing due to the fact that for generations crops have been taken off the land and nothing has been put back into it. Increasing population is also causing large tracts of land to be opened up in an endeavour to meet the demand for food, and these are being treated in a similar manner. Various schemes have been adopted to persuade the African that it is impracticable and uneconomical to produce crops over a continuous and long period of cultivation with complete disregard to maintaining the fertility of the land. Artificial fertilizers are beyond the reach of the Africans and although many farmers know that green manure is advantageous, they prefer to grow food crops on such land. Some of the better African farmers are gradually beginning to realize that the use of organic manures is to their advantage if they wish to produce better crops. Animal manure is much the best fertilizer but as the supply of this in the Kikuyu reserve is limited, compost making has been introduced, and it is felt that this will help to solve the problem of obtaining an adequate supply of manure at a very low cost.

That some initial progress has been made is indicated by the fact that approximately 10,000 tons of compost were made in the Fort Hall district in 1950 by African farmers, schools, Local Native Councils and at markets. Many farmers are beginning to appreciate the value of compost made by the system described below as, for little work and practically no cost, they can produce a large quantity of organic manure. It has been and still is a practice amongst the Kikuyu to purchase manure, often from European farms, for as much as Sh. 60 to Sh. 120 for a 3-ton load compared with Sh. 8 per ton from two factories developed at the beginning of the scheme by the Local Native Council and from compost factories established at markets to utilize the daily sweepings. The system was first introduced into the schools to provide instruction, and demonstration throughout the district. One school that had started this system of compost making in August, 1949, had made 25 tons by the following long rains for use on the school holding. An individual farmer in the same period made 18 tons of compost. Both he and the school had extremely good results from their crops.

The preparation of compost in stacks has been adopted in preference to the pit method which was found in the Fort Hall district to be too arduous for turning, and so just became a rubbish dump. The stack method was therefore introduced as it provided for rapid decomposition of organic residues in three to four months. Further advantages of the stack method so far as the African is concerned are that the *bomas* which are built to assist this method are easy to maintain and keep tidy and they retain a compost stack.

Selection of Sites for Compost Factories.

If the farmer keeps cattle, the compost factory is generally constructed near the cowshed so that the soiled bedding is readily accessible to mix with the trash as a rotting agent. The factory should be a reasonable distance from the living quarters for hygienic reasons, and at the same time should be as near as possible to the shamba so that the cartings of the compost does not become too difficult. In the Kikuyu reserve, holdings are generally severely fragmented which aggravates the transport problem. The bench terracing and heavy manuring of land near the homestead is being encouraged. If the farmer has no cows, which is the case with the majority of the school small holdings in the Fort Hall district, then the compost factory is best sited at one end of the terraced lands to simplify work. It is very important to remember that the factory should be sheltered from strong winds and sun.

Construction of the Compost Factory.

The factory consists of three entirely separate *bomas* of varying sizes placed with their long sides parallel and separated by a 3 ft. gap. The first *boma* is 12 ft. × 8 ft. the second is 11 ft. × 7 ft. and the third is 10 ft. × 6 ft. and all three maintain a constant height of 5 ft. The gradual reduction in size, that is by one foot, of both the length and the breadth of the *bomas*, is due to the fact that decomposition causes the material to

shrink. It is essential that the height of 5 ft. should be maintained in order to curtail the area of exposure to the sun, thus avoiding undue drying.

Each *boma* is built of strong wattle uprights or other wooden posts sunk into the ground at intervals of 2 ft. Cross-members are fastened to the sides of these uprights at intervals of 1 ft. to the height of 5 ft. In the centre of each of the long sides is a gate with slip rails similar to that used for cowsheds and wide enough to simplify the charging and turning of the compost material. *Bomas* so constructed will not last longer than a period of 18 months to 2 years as they rot and break away. Permanent *bomas*, however, can be constructed by planting "Mukunguku" cuttings (*Commiphora* sp.) or some similar type of tree at 1 ft. intervals along the sides of the previously constructed *bomas* at the first rains. The off-shoots from the saplings are cut away from the inside and the outside of the *bomas* and the side-shoots trained from one "Mukunguku" upright to another in the form of cross-members. By the time the wattle posts have rotted, the "Mukunguku" structure is firmly established.

Where there is sufficient material available to make compost, *bomas* of the sizes already mentioned have proved the most practical, but where there is not an adequate supply of material, the sizes should be reduced accordingly.

Preparing the Activator.

Where cattle are available.—All crop residues including maize stalks, banana leaves and weeds are collected and cut into 6-in. lengths to facilitate decomposition. Where cattle are available, they are bedded down daily to collect manure, soak up urine and break down the bedding. By the end of each month a good layer of manure and rotting bedding will have accumulated and this is used in conjunction with other animal manures, e.g. goat and poultry droppings and ashes for mixing with the bulk trash as a rotting agent in charging the first *boma*.

Without cattle.—If animal manures are unobtainable, which is often the case with the small school holdings, excellent compost can be made by using luscious green schrubs, e.g. "Maigoiya" (*Coleus Barbatus*), "Mithakwa" (*Vernonia Holstii*) or other local plants as rotting agents. They should not be collected earlier than the day previous to charging the *boma* lest their rotting value diminish. They should be cut into 6-in. lengths at the time of charging the stack.

"Maigoiya", which grows abundantly above 5,000 ft. in this area, serves a dual purpose. It is used as a wash stop along the top lines of all terraces. It is a quick-growing shrub and roots readily from cuttings. If the wash stops are well maintained and not allowed to go to wood, the farmer has a ready supply of rotting agent whenever the "maigoiya" hedges are trimmed and cut back.

Another method, after the first charge of compost has been turned the first time, is to use some of the already rotted material as a starter and in this way the process can be continued indefinitely.

Charging the Stack.

A layer of the cut up trash is placed 1 ft. deep in the bottom of the first *boma*. On top of this is placed a 6-in. layer of rotting agent, either farmyard manure, compost from the previous charge or green material which is spread on top of the heap and slashed. Each layer should be wetted thoroughly, and trodden down lightly, and the process continued with alternating layers of trash and activator to a height of 5 ft. The heap should not be so compacted as to prevent aeration as a high temperature must be readily developed. It is not desirable to have sticks mixed in with the charge. A few days after charging, the stack drops 6 in. to a foot when a final layer of trash and rotting agent should be added. Finally the stack is covered with a layer of long dried grass to prevent evaporation of moisture. As adequate moisture is essential to the process of decomposition, it is important that every layer of the stack should be thoroughly wetted when charging the *boma*. If the stack is too dry it merely becomes a haystack, remains cool and takes months to rot down.

The heat of the stack can be tested by thrusting a stick into the centre. If it comes out cold and wet, the stack must be turned and remade, actually adding water as necessary. If the stack heats up correctly, it will cool down by the end of a month when it requires to be turned.

Turning.

The object of turning is to ensure proper mixing, wetting and aeration in order to hasten decomposition. The material at the bottom of the stack will have rotted quicker than at the top of the stack and the sides. Therefore turning is essential to make rotting more thorough.

The material in the first *boma* is now turned into the second *boma*, adding water as appropriate, and the former is recharged as above. At the end of the second month the material in No. 2 *boma* is turned into No. 3, No. 1 *boma* is turned into No. 2 and No. 1 *boma* is recharged, adding water at each stage. At the end of the third month, if fermentation has been progressing satisfactorily, the compost in No. 3 *boma* should be spread on the *shamba* or removed to a storage stack. This process of monthly turning can be continued indefinitely as long as material is available.

If *boma* No. 1 is fully charged, then at the end of three months the farmer ought to obtain about 5 to 6 tons of compost from No. 3 *boma* when completely ready and broken down.

If the material is not properly decomposed by the end of the third month, a new *boma* should be made for a fourth turning, as, if the compost is applied to the *shamba* in this state, the continuation of decomposition in the soil will be detrimental to the growth of the plants. Compost should always be fully mature before applying to the *shamba*.

Storage.

The compost should be stored if it is not required immediately for, if it is left lying around, the material leaches rapidly. The storage stack must be well constructed and not merely an untidy heap. The building of a covered storage shed is an added advantage, while the stack should be covered with long dried grass to prevent evaporation, leaching and fly breeding.

THE ROOT SYSTEMS OF SOME BRITISH SOMALILAND PLANTS—IV

By P. E. Glover

(*Received for publication on 2nd April*, 1951)

Acacia bussei Harms Vernacular "Galol" (Diagram 32).

Vegetation type: *Acacia bussei*, open woodland and plateau grass.

Locality: Inland Plateau, Haleya 5 miles south of Hargeisa on Hargeissa-Berbera Road. Altitude, 4,500 ft. (approx.).

Annual rainfall: 17.8 in. (Hunt, 1945).

Acacia bussei Harms is a common tree on the plateau and in parts of the Haud. Its optimal altitude range is from 3,000 to 4,500 ft., but it has also been seen at altitudes of 2,500 ft. and 5,000 ft. It is a medium-sized tree up to 30 ft. high, and is conspicuous by its numerous, white, swollen thorns.

The tree examined at Haleya was about 4 m. high, and the diameter of its bole 1 m. above ground level was 14 cm. It was growing on a slight south to north slope, with the longest roots on the north side.

A horizontal dissection was made of its roots. These had an overall lateral extent of 14 m. in one direction and 9.25 m. in another. Most of the lateral roots came off the tap-root at a depth of 15 cm. below the soil surface. The thickest root at the point of origin from the tap-root was 5 cm. in diameter. All the roots examined went out more or less horizontally, and did not penetrate into the soil to a greater depth than 30 cm. There were numbers of small, secondary lateral roots on the tap-root and near the points of junction of the main lateral ones.

The roots of numbers of *Acacia bussei* Harms, were observed exposed in erosion gulleys, or by wind erosion and in every case profusely developed, shallow laterals with a thick tap-root that tapered down suddenly and did not seem to penetrate deeply into the soil, were seen.

Acacia bussei Harms, does not seem to be able to withstand over-grazing, trampling and wind erosion, for there are large areas of dead trees in many parts of the country where over-grazing and other devastation has been severe and in almost every case the majority of these dead trees are *Acacia bussei* Harms (Hunt, 1945, Glover, 1950).

Gillett (1941) in his discussion on the *Acacia bussei* Association writes, "The superficial root system of the *Acacia* is very extensive, for instance, one small individual 3.5 m. high was found to possess a root reaching about 15 cm. below the surface to a distance of 18 m. from the trunk. Thus rain falling in the spaces between the trees is utilized by them".

That is true, but this shallowness is the thing that renders these trees most vulnerable to trampling, on bare soils denuded of other plants.

Young plants of this tree are grazed by all stock. During the dry season the branches of larger trees are cut down for animals to graze. The bark is stripped off for making camels mats and rope. It is also used as a dye, and for tanning leather. The roots are used in making the lattice work of "gurhgis" and their bark for making rope. The young thorns called "Ambul" are eaten by the Somalis when they are soft and succulent. This tree is vital to the nomadic Somali economy and the rate at which it is dying out is due, in part, to the inability of its root system to withstand trampling, over-grazing and other rough usage.

Acacia spirocarpa Hochst. Vernacular "Gurah" (Digaram 23, figure 3, part III).

Vegetation type No. VII: Haud sub-type Acacia tree and shrub.

Locality: Guban, Ged Dobo. Latitude 10° 7′ 30″ N. (Approx.) Longitude 45° 12′ 30″ E. (Approx.) Altitude 1,900 ft.

Annual rainfall: 8 in. to 10 in. (Hunt, 1945).

Acacia spirocarpa Hochst. is a very common tree throughout the country, especially in river valleys, in depressions and around the edges of "Ballehs" and "Dohos" (seasonal swamps). It has an altitude range from sea level to 5,000 ft. or more.

The tree examined at Ged Dobo had been cut off at a height of 1.8 m., but its lateral branches reached up to 3 m. It had a crown diameter of 6.2 m. and a trunk diameter of 27 cm. at ground level. There was a stout tap-root that did not taper suddenly and looked as if it penetrated deeply into the soil. The tap-root had three main lateral roots coming off

it at different points between the surface and 45 cm. down. Roots of 10 cm., 9 cm. and 8.5 cm. thick respectively at their points of origin, grew out horizontally beneath the soil to distances of 8.4 m., 14 m. and 10.6 m. They tapered rapidly from their points of origin to thicknesses of 6 cm., 6 cm. and 4 cm. respectively in a distance of 4 m. The root tips of these laterals were not traced as their ends all turned and grew downwards. The soil was the usual sandy alluvium at Ged Dobo.

From this tree and the roots of others seen in the walls of tugs in different parts of the country, it would seem that *Acacia spirocarpa* Hochst. has a well developed, deep root system as well as an extensive lateral one.

The plant appears to be resistant to overgrazing and trampling, but its branches are extensively cut by the local nomads in times of drought as fodder for their stock. This seems to lower its resistance and increase its vulnerability to attacks by borer beetles. The seed pods called "Damel" are eaten by the Somalis when they are fresh and green. When they are dry they are collected and fed to stock. The bark is stripped off and used for making camel mats and rope. The roots are used for the lattice work in "gurghis" when that of more suitable trees is not available.

Commiphora ancistrophora Chiov. Vernacular "Dundas" (Diagram 33).

Vegetation type No. VIII: Haud *Commiphora-Acacia* tree, shrub and grass.

Locality: Haud, Alablah. Latitude 8° 2′ N. (Approx.) Longitude 45° 1′ E. (Approx.) Altitude 2,500 ft.

Annual rainfall: 6 in. to 8 in. (Hunt, 1945).

This plant is common in most parts of the Haud. It is a small tree which may reach a height of 4 m. Its stem is usually thinner at ground level than it is 15 cm. or 20 cm. higher up. The plant examined at Alablah was 1.2 m. high with a crown diameter of 2 m., an overall lateral root spread of 19 m. and a maximum root penetration of 57 cm. Its stem was 5 cm. thick at ground level and between ground level and a depth of 57 cm. 12 large lateral roots were given off. At 57 cm. beneath the surface a white, shaley limestone layer appeared which deflected the tap-root sideways. The roots were dark-brown in colour, hard and smooth and there were very few secondary rootlets.

The soil was the yellow-red, sandy soil of the Haud, which became harder and more compacted at a depth of about 33 cm. From there downwards occasional pebbles and artefacts occurred. This plant appears to be resistant to a certain amount of trampling, but does not seem to survive cutting or fire.

Commiphora ancistrophora Chiov. has a pungently scented volatile sap, which sprays out when a branchlet is bent backwards. The sap kills camel-flies (*Hippoboseids*) if it is sprayed on to them.

The Somalis chew the gum of this plant and the leaves are grazed by them.

Commiphora erythræa Engl. Vernacular "Hagar ad" (Diagram 34).

Vegetation type: As for *Commiphora ancistrophora* Chiov.

Locality: As for *Commiphora ancistrophora* Chiov.

Annual rainfall: As for *Commiphora ancistrophora* Chiov.

Commiphora erythræa Engl. like *Commiphora ancistrophora* Chiov.. is a common tree of the Haud. It may reach a height of 5 m.

The plant examined at Alablah was 3.25 m. high, had a crown diameter of 2.3 m., and the overall spread of its lateral roots was 10.75 m. in one direction and 7.9 m. in the other. The roots were brown in colour, smooth and had very few secondary rootlets. The tap-root after penetrating to a depth of 75 cm. turned upwards and grew out laterally. The lateral roots grew out from the tap-roots at depths varying from 20 cm. to 70 cm. and continued sideways more or less horizontally.

The top soil was the usual yellow-red, sandy soil of the Haud. This became harder and more compressed to a depth of 33 cm. and at 75 cm. a layer of hard, shaley limestone appeared.

Commiphora erythræa Engl. appears to be resistant to a certain amount of trampling, but not to severe cutting or fire. The leaves and fruit of this tree are eaten by stock.

Commiphora sp. Vernacular "Garon Medu" (Diagram 35).

Vegetation type: As for *Commiphora ancistrophora* Chiov.

Locality: As for *Commiphora ancistrophora* Chiov.

Annual rainfall: As for *Commiphora ancistrophora* Chiov.

Commiphora sp. "Garon Medu" is also a very frequent tree in the Haud. It may grow up to a height of 3 m. or 4 m. The plant examined was 1.3 m. high with a crown diameter of 1.8 m. Its trunk was 5 cm. thick at ground level and its lateral root spread along the longest axis

was 12 m. The tap-root was not traced to its end, but it is suspected that it did not penetrate further than the layer of shaley limestone which was never far below the surface. The roots were smooth, blackish-grey in colour and had very few secondary rootlets. Most of them branched off horizontally from the tap-root in the first 25 cm. from the surface.

The top soil was the usual yellow-red, Haud sand, which becomes more tightly compressed at a depth of about 30 cm. This plant appears to be resistant to a certain amount of trampling, but not severe cutting or fire. Its leaves and young shoots are grazed by stock.

Platycclphium cynanthum Harms. Vernacular "Sabansabadoh" (Diagram 36).

Vegetation type: As for *Commiphora ancistrophora* Chiov.

Locality: As for *Commiphora ancistrophora* Chiov.

Annual rainfall: As for *Commiphora ancistrophora* Chiov.

This plant is locally frequent in parts of the Haud, but is not evenly distributed throughout the vegetation, and usually occurs in stands of a few individuals at a time. It is really a very well developed, tall shrub, for it is most often made up of a number of stems which may each grow to a height of 4 m. or 5 m.

The plant examined at Alablah was 3.4 m. high, had a crown diameter of 2.6 m., an overall root spread of 14 m., while its roots penetrated the soil to a depth of 59 cm. There were great numbers of lateral roots growing out horizontally from a few centimetres below the soil surface to 50 cm. down in fairly clearly defined layers. There was no tap-root, and almost all of the lateral roots had their counterpart in a stem above ground. They varied in thickness and some of them were 3 cm. or 4 cm. thick at their junction with the stems. The bark of the roots was yellowish-grey on the outside, bright yellow inside and more or less fleshy. Unlike the *Commiphora* spp., the roots of *Platycelyphium* had numerous secondary rootlets on them, especially towards their tips. There were numbers of bacterial nodules on the secondary rootlets. These roots showed the same clockwise twist so common in many of the other ones already described.

The top soil was the usual yellow-red sand of the Haud which became more tightly compacted about 30 cm. beneath the surface. A layer of pebbles containing numbers of artefacts apeared at a depth of about 36 cm. and at 60 cm. a layer of shaley, white limestone appeared.

Platycelyphium cyananthum Harms seems to be resistant to fire and to cutting, as many of the trees examined showed signs of frequent cutting and some of them had fire scars on them.

The large, fresh, green leaves of this plant are relished by stock and the Somalis cut the stems in the dry season to provide fodder for their animals. The long, thin, straight stems are used in the construction of "gurghis".

Conclusions

From the above diagrams and descriptions the following conclusions may be drawn:—

(1) *Acacia spirocarpa* Hochst. had a deep root system as well as a well developed, shallow lateral one.

(2) All the other trees described in this group had extensive shallow lateral root systems.

(3) *Acacia bussei* Harms is particularly vulnerable to over-grazing and other types of devastation.

(4) All the trees described from the Haud had extremely shallow root systems because a layer of hard, shaley limestone was usually struck at depths ranging from 50 cm. to 100 cm. beneath the surface of the soil.

Further Notes on Some other Root Systems

(1) *Acokanthera nabaio* Schweinf. was seen at Gaan Libah to have shallow, lateral roots up to 12 m. or 15 m. in length.

(2) *Acacia ethaica* Schweinf. also had an extensive shallow, lateral root system with roots up to 12 m. or 15 m. in length.

(3) *Acacia mellifera* Benth, in the Haud, had an extensive lateral root system with some roots from 10 m. to 15 m. in length.

(4) *Balanites orbiculars* Sprague in the Guban often had shallow, lateral roots up to 12 m. or 15 m. in length, but it also had roots which penetrated deeply into the soil.

(5 & 6) *Cadaba rotundifolia* Forsk. and *Mærua somalensis* Pax in the Guban (like Balanites), had extensive lateral, as well as deep root systems. About 3 miles south, up the "tug" from Tokoshe near Zeilah, it was noticed that the soil was very gravelly and that there was a layer of hard clay about 1.6 m. below the surface. An examination of the "tug" wall showed that the hard clay layer caused a concentration of roots in the gravel above it. Even in the case of *Balanites orbicularis* Sprague, whose roots

did not penetrate into the clay, despite their great lateral development. *Mærua somalensis* Pax and *Cadaba rotundifolia* Forsk. had root concentrations above the clay layer, but some of their roots did penetrate into it.

(7) *Dobera glabra* A.DC. in the Guban had a very extensive and robust lateral root system as well as a deep one. Gillett (1941) writes, "A feature of the sub-desert are the alluvial fans in which the "tugs" from the interior spread out and disappear. In these and in adjacent deep-soiled plains ground-water is within reach of deeply-rooted species, at any rate at certain seasons. *Balanites orbicularis* Sprague and *Mærua somalensis* Pax in the west, and *Zygophyllum hilderbrandtii* Engl. in the east are the principal of these. These three species are all evergreen and deeply rooted. The roots of a 2.75 m. bush of *Dobera glabra* A.DC. in the sub-desert were seen penetrating 12 m. of lava and reaching a sandy river bed where they were still over 5 cm. in diameter".

(8) *Juniperus procera* Hochst. on Gaan Libah had a shallow lateral root system with roots up to 10 m. in length, but poorly developed for the size of the trees. These trees are easily blown over by wind, and are very vulnerable to over-grazing, trampling and soil erosion.

(9) *Zizyphus mauritana* Lam. is a common tree on tug banks in most parts of the country, and was often observed to have large and very extensive lateral roots, as well as roots that appeared to grow deeply downwards into the soil.

In the case of the *Commiphoræ* a shallow extensive root system does not seem to be a peculiarity only of the three species discussed earlier, for Gillett in his description of the Haud vegetation writes, "The bush possesses an extensive superficial root system so that rain falling on the open ground between them can be utilized.. For instance, a small individual *Commiphora cuspidata* Chiov. 1.2 m. high, was found to have roots spreading, between 15 cm. and 35 cm. from the surface, to 8.5 m. distance".

No. VI. A Composite Root Bisect showing the Root Habits and Relationships of 15 *Species in a Bisect* 17 *m. long.* Weaver and Clements (1929). (Diagram 37.)

Vegetation type: Haud (*Commiphora-Acacia* tree, shrub and grass.

Locality: Haud, Hrai Hede. Ten miles east of Duruksi on the Boundary Road. Latitude 8° 29′ N. (Approx.) Longitude 45° 32′ E. (Approx.) Altitude 2,540 ft.

Annual rainfall: 6 in. to 8 in. Hunt, (1945).

In making an ecological study of the vegetation of the Haud by means of the 0.25 Metre Quadrat Method, West (1939), and the Line Transect Method, Weaver and Clements (1929), it was found that the average basal cover of the vegetation was very low, (i.e. 4.055 per cent) over a considerable area. Therefore in order to discover what the controlling factors were, other than over-stocking, a root bisect 17 m. long was made in typical Haud vegetation on the usual yellow-red, sandy soil.

The first 30 cm. of soil was fairly loose and sandy but after that it became harder and more tightly compacted. White, shaley limestone was struck at depths varying from 15 cm. to 1 m., along the length of the trench. This pit showed a soil profile, which bore out Dr. Gethin-Jones remarks in "Soil Sample 1" (Part 1, p. 99).

Reference to the diagram shows that most of the root activity was confined to the first 45 cm. of soil. Small, filamentous secondary rootlets were very numerous in this zone and almost all of the lateral branching took place in it. From there down to a depth of 60 cm. there was less root activity, there were fewer secondary rootlets and lateral branching was much less frequent. From that point down to the stone level, the soil became very hard and there was little root activity, except in the deep rooted species such as *Commiphora* sp. "Tubuk" and *Ehretia orbicularis* Hutch. and Bruce whose tap-roots penetrated down as far as the stone level.

A similar phenomenon to that noted at Ged Dobo in the case of *Adenium somalense* Balf. f., in which certain roots were sent upwards towards the soil surface, was seen in an unidentified plant with the vernacular name of "Tire". This plant had a succulent, shallow root system from which smaller roots grew up towards the soil surface. It would seem that the phenomenon might indicate that these plants are true desert plants and the habit of sending roots upwards is an adaptation to make every possible use of the slightest amount of moisture that may become available in the shape of rain or dew.

The fact that most of the root activity of the plants in the bisect was confined to the first 45 cm. of soil, would seem to indicate that moisture from the usual shower does not penetrate very much deeper than that and therefore the roots have grown in a way which would be likely to make best use of it (Glover, 1950).

Another point of interest is the fact that seedlings and small plants of *Aristida* sp., *Latipes senegalensis* Kunth, and *Enneapogon cenchroides* (Licht.) Hubb. congregated in numbers at the bases of the large, deep-rooted plants such as *Ehretia orbicularis* Hutch. and Bruce and *Commiphora* sp. "Tubuk".

Ten 0.25 m. quadrats were listed along the surface of the bisect and it was found that the average basal cover of the plant parts above ground was 2.168 per cent on that sector.

The total basal cover for annual ephemeral grasses was 1.416 per cent; perennial grasses 0.56 per cent; annual ephemeral forbs 0.88 per cent; perennial forbs 0.144 per cent and 0.88 per cent of the surface of the soil was covered by an encrustation of *Alga.*

From the figures given above it would seem that the basal cover of the plant parts above ground was very low, but further reference to the diagram shows that almost all the perennial plants had widely developed interlacing root systems extending from just below the surface to a depth of 45 cm. This might make it impossible for the area to carry a higher perennial plant cover under the existing conditions of soil and climate.

In the case of annual ephemeral grasses and forbs, which are very shallow rooted and whose life is of only a few weeks duration, the cover might be expected to depend to a great extent on the number of viable seeds in the soil and the number of these able to germinate and complete their life cycles on the moisture available in the first few centimetres of soil during the wet season.

The following plants appeared in the bisect (Diagram 37):—

Aristida kelleri Hack. Vernacular "Birhe", annual ephemeral grass.

Aristida papposa Trin. and Rupr. Vernacular "Machen", annual ephemeral grass .

Barleria sp. Vernacular "Aran-Ar", perennial herb.

Brachiaria glauca Stapf. Vernacular "Baldole Agar" annual ephemeral grass.

Chrysopogon aucheri (Boiss.) Stapf. Vernacular "Daremo", perennial grass.

Commiphora sp. Vernacular "Tubuk", small tree.

Cissus sp. Vernacular "Armo", climber.

Cucurbit. Unidentified, climber.

Enneapogon cenchroides (Licht.) Hubb. Vernacular "Baldole", annual ephemeral.

Ehretia orbicularis Hutch. and Bruce. Vernacular "Himir", small tree.

Grewia sp. Vernacular "Ho-Hob", woody shrub.

Indigofera ruspoli Bak. f. Vernacular "Jelab", perennial woody herb.

Latipes senegalensis Kunth. Vernacular "Chebioke", annual ephemeral grass.

Sida sp. Vernacular "Salo-Weineye", annual ephemeral herb.

Unidentified. Vernacular "Tire", woody herb with succulent roots.

In summary the following conclusions may be drawn:—

(1) The zone of maximum root activity for all species in the bisect was from just below the soil surface down to a depth of 45 cm.

(2) Although the average basal cover of the parts above ground was only 2.168 per cent, the lateral roots of the shrubs and perennial herbs formed an interlacing network from just below soil level to a depth of 45 cm. Therefore it is unlikely that a greater cover of these plants, than that already in existence, could be maintained under the existing conditions of soil and climate.

(3) The annual grass and forb cover would seem to depend almost entirely on local showers of rain and availability of viable seed.

(4) Shallow lateral root systems would appear to be an adaptation to desert conditions and shallow moisture penetration.

(5) The possession of shallow, lateral root systems might be likely to render the plants particularly vulnerable to trampling, overgrazing and other types of devastation.

SUMMARY

The significance of an understanding of root systems in regard to existing conditions and redemption of devastated areas in relation to the geography, soils, vegetation cover and carrying capacity is essential.

Six groups of plants were examined in four different vegetation types, i.e. Succulents, Grasses, Forbs, Shrubs (including those with edible, tuberous roots), Trees and a 17 m. composite bisect in the Haud.

Each of the 37 plants examined and the composite bisect was referred to its vegetation type, its exact locality, altitude and rainfall. A detailed description of each root was given supported by detailed scale diagrams carrying the soil profile of the pit in which the plant

was examined. In addition ecological remarks on the plant and its economy were given. Where practical the vertical pit "Bisect Method" of Weaver and Clements (1929) with a slight modification was used. A few horizontal dissections of the surface root were made. In some cases both methods were employed for the same plant.

Part I—Succulents

The following plants were examined:—

Adenium somalense Balf. f. Var. *Crispum* Chiov. Vernacular "Badiawen", in the vertical and horizontal planes.

Alœ sp. Vernacular "Daar", in the vertical plane.

Caralluma sp. Vernacular "Udapteis", in the vertical plane.

Euphorbia sp. Vernacular "Dibu", in the vertical and horizontal planes.

Sansevieria sp. Vernacular "Hig" in the vertical and horizontal planes.

In this group microscopic sections of the root tips were made.

The distinctive characters of the group were the anti-geotropic habit of the fibrous roots growing off swollen tubers beneath the crown influence zone, and the presence of tuberous underground storage organs which sustain them under arid conditions. The anti-geotropic character of the fibrous roots beneath the crown influence zone seems to be a general adaptation of plants in arid areas.

Part II—Grasses

The following grasses were examined in the vertical plane only:—

Andropogon cyrtocladus Stapf. Vernacular "Dur".

Aristida kelleri Hack. Vernacular "Birhe".

Aristida papposa Trin. and Rupr. Vernacular "Machen".

Chrysopogon aucheri var. *Quinqueplumis* Stapf. Vernacular "Daremo".

Eragrostis hararensis Chiov. Vernacular "Guban Gub".

Panicum turgidum Forsk. Vernacular "Dungara".

Sporobolus marginatus Hochst. Vernacular "Dihi".

Throughout the Plateau region grass root systems were essentially fan-shaped and shallow, which may account for the susceptibility of *Andropogon cyrtocladus* Stapf and *Chrysopogon aucheri* (Boiss.) Stapf to fire.

Panicum turgidum Forsk. of the Guban is deep rooted. An intensified development of the lateral roots was always noted in alluvial soil when clayey layers were encountered.

Herbs

The following herbs were studied in the vertical plane only:—

Aerva tomentosa Forsk. Vernacular "Sorna".

Anticharis linearis Hochst. ex Acshers. Vernacular "Indatire".

Citrullus vulgaris Schrad. Vernacular "Unun".

Indigofera ruspoli Bak. f. Vernacular "Jelab".

Indigofera spinosa Forsk. Vernacular "Machin".

Oldenlandia sp. Vernacular "Manjaaso".

Mollugo sp. Vernacular "Karo".

Sida sp. Vernacular "Mirageljire".

Tephrosia sp. Vernacular "Farader" or "Timader" or "Lebi-yero".

All the herbs were studied in the Guban. The *Indigoferæ* at Ged Dobo and the other herbs at Silil. In general all the Guban herbs were fairly deep rooted as well as having extensive lateral systems except *Tephrosia* at Silil. The Legumes had pronounced bacterial nodules (except *Tephrosia*). At Silil the distinctive colourings of the roots of different species were noted.

Part III—Shrubs

The following plants were studied:—

Acacia misera Vatke. Vernacular "Khansa", in the horizontal plane.

Acacia sp. Vernacular "Sarman Jif-Jif". In both the vertical and horizontal planes.

Acacia socotrana Balf. f. Vernacular "Jerin". In the horizontal and vertical planes.

Blepharispermum fruticosum Klatt. and Schinz. Vernacular "Gehait". In the vertical plane only.

Entada flexuosa Hutch. and Dalz. Vernacular "Farader". In the horizontal and vertical planes.

Erythrina rotundata-obavata Bak. f. Vernacular "Yo-oh". In the horizontal and vertical planes.

Iphiona rotundifolia Oliv. and Hiern. Vernacular "Gegabod". In the vertical plane only.

Salsola feotida Del. Vernacular "Gulan". In the vertical plane only .

Secamone punctulata Decne. Vernacular "Geseriad". In the vertical plane only.

Entada flexuosa Hutch. and Dalz. and *Erythrina rotundata-obovata* Bak. f. of the Haud had extensively developed lateral roots which were swollen, fleshy tubrous organs. *Acacia socotrana* Balf. f., *Iphiona rotundifolia* Oliv. and Hiern, *Salsola fœtida* Del., and *Secamone punctulata* Decne. had very well developed vertical and lateral root systems in the Guban.

The well developed, shallow lateral root systems of *Acacia misera* Vatke and Acacia sp. "Sarman Jif-Jif" seemed to prefer stoney gravelly soil, while *Acacia socotrana* Balf. f. seemed to prefer deep, sandy soil.

Tightly compacted soil layers or clay layers induced more profuse lateral root development above them.

The Guban shrubs, in contrast to the Haud shrubs, were deep rooted and might therefore be expected to be less sensitive to trampling and over-grazing. *Blepharispermum* on the other hand which appeared to be fire-resistant, may be an exception.

Part IV—Trees

The following trees were examined in the horizontal plane:—

Acacia bussei Harms. Vernacular "Galol".

Acacia spirocarpa Hochst. Vernacular "Gurah".

Commiphora erythræa Engl. Vernacular "Hagar Ad".

Commiphora ancistrophora Chiov. Vernacular "Dundas".

Platycelyphium cyananthum Harms. Vernacular "Sabansabadoh".

All the trees examined had essentially shallow wide-spread root systems. *Acacia spirocarpa* Hochst. alone possessed a deep root system as well as an extensive lateral one.

The lateral roots of the *Commiphora* spp. came off the main tap-root at right angles. These trees are susceptible to trampling, fire and over-grazing.

Platycelyphium cyananthum Harms has a layered shallow root system which enables it to withstand severe cutting and even fire.

Most of the "forests" of dead trees in British Somaliland are of *Acacia bussei* Harms, partly because these trees are of economic value to the Somalis and partly because their shallow lateral root systems render them particularly susceptible to all types of devastation.

Notes on the roots of the following, additional trees which had been observed, but not dissected, were made.

Zisyphus mauritiana Lam. Vernacular "Gob".

Juniperus procera Hochst. Vernacular "Deyib".

Acokanthera schimperi Schweinf. Vernacular "Wabe".

Acacia etbaica Schweinf. Vernacular "Sug Sug".

Acacia mellifera Benth. Vernacular "Bilel".

Commiphora cuspidata Chiov.. Vernacular "Didin".

Balanites orbicularis Sprague. Vernacular "Kulan".

Cadaba rotundifolia Forsk. Vernacular "Kalan Baror" .

Mærua somalensis Pax. Vernacular "Kalan Weid".

Dobera glabra A.DC. Vernacular "Garas".

Composite Root Bisect.

A 17 m. root bisect was dug in order to determine the type and extent of root competition, so as to determine the possible effect of over-stocking on the low ground cover, (as determined by the 0.25 m. List Quadrat Method) in the Haud. It was found that the average basal plant cover of the bisect area was 2.168 per cent .The zone of maximum root activity was in the first 45 cm. down. The shrubs and perennial herbs formed an interlacing network in this zone, while seedlings of small grasses clustered at the bases of the large deep rooted plants. These facts may be taken to indicate that the annual grass and forb cover depends mainly on light local showers, and that shallow, lateral root systems would appear to be an environmental adaptation which would render the plants vulnerable to trampling and denudation. In short the root systems indicate that a marked increase in the ground cover under existing climatic and soil conditions could not be expected, while overstocking should be strictly guarded against.

The swollen roots in the composite bisect showed the same anti-geotropic characters as the succulents of the Guban.

ACKNOWLEDGMENTS

My thanks are due to the British Somaliland Military Government and the Director of Agriculture and Grazing with whose assistance and under whose administration this work was

done, to my wife who is responsible for the drawings and tracings and whose devoted and untiring assistance has made this work possible and to Captain R. Raubenheimer, who helped me in the field in the early stages of the work. My thanks are also due to Signor Anzaghi (Geometra) for the lettering and reproduction of the drawings, and to Hussein Weid and all my Somali staff who assisted in digging the roots and in many other ways.

BIBLIOGRAPHY

Balfour, E. B. (1944).—"The Living Soil." Faber and Faber, Ltd., London.

Bally, P. R. O. (June, 1945).—"The East Africa Succulents VI." Journal of the East African Nat. Hist. Soc. Vol. XVIII, Nos. 3 and 4 (83 and 84).

Bayard, Hora F. and Greenway, P. J. (1940). —"Check Lists of the Forest Trees and Shrubs of the British Empire No. 5, Tanganyika Territory Part 1."

Bower, F. O. (1939).—"Botany of the Living Plant." McMillan and Co. Ltd., London, 1939.

Chiovenda, F. (1929 and 1932).—"North-Eastern British Somaliland." Kew Bulletin of Miscellaneous Information No. 8. 1931.

Edwards, D. C. (1942).—"A Survey of the Grazing Areas of British Somaliland." M.S.

Eig, A. (1932).—"Les elements et les groupes phytogeographiques auxiliaires dans la flore palestinienne." Berlin, 1932.

Farquharson, R. A. (1929).—Annual Agricultural Report for 1929, Somaliland Agricultural and Geological Department. Flora of Tropical Africa. Vols. I to X, Part I, 1868-1937 by various authors.

Gethin-Jones, G. H. (1942).—"Report on Soil Samples from British Somaliland." ex D. C. Edwards, 1942.

Gillett, J. B. (1941).—"The Plant Formations of Western British Somaliland and the Harar Province of Abyssinia." Kew Bulletin, No. 1, 1941.

Glover, P. E. (1939).—"A Preliminary Report on the Comparative Ages of some Important East African Trees in Relation to their Habitats." South African Journ. of Sci. Vol. XXVI, 1939.

—— (1950).—"Rain Water Penetration in British Somaliland Soils." E.A. Agric. Journ. Vol. XVI No. 1., July, 1950.

Hall, Sir A. D. New and Revised Edition by G. W. Robinson, 1944. (1902).—"The Soil. An Introduction to the Scientific Study of the Growth of Crops." John Murray, Albemarle St., London, W.

Hunt, J. A. (1945).—"Report on General Survey of British Somaliland." Government Printer, Somalia, 1945.

Hunt, J. A. and Viney, N. M. (1945).— "Gazetteer of British Somaliland Place Names." M.S.

Jack, G. V. and Whyte, R. O. (1939).—"The Rape of the Earth. A World Survey of Soil Erosion." Faber and Faber, London, 1939.

James, W. O. (1936).—"An Introduction to Plant Physiology." Oxford at the Clarendon Press. 1936.

Macfadyen. (1933).—"The Geology of British Somaliland." 1933.

Picard, Leo. (1943).—"Structure and Evolution of Palestine." The Geological Department, Hebrew University, Jerusalem, 1943.

—— (1944).—Report of the Soil Conservation Committee, Sudan Government, McCorquodale and Co. (Sudan) Ltd.

Russell, E. J. (1932).—"Soil Conditions and Plant Growth." Longmans Green and Co., London, 1932.

Scott, J. D. and Van Breda, N. G. (1939).— "Preliminary Studies of the Root Systems of *Euphorbia mauritanica Euphorbia burmanni* and *Ruschia multiflora* on the Worcester Veld Reserve." S. Afr. Journ. Sci. Vol. XXXVI, December, 1939.

Vageler, P. (1933).—"An Introduction to Tropical Soils." MacMillan and Co., London. 1933.

Wayland, E. J., Brasnet, N. V., Bisset, C. B., Martin, W. S. (1938).—"Soil Erosion and Water Supplies in Uganda." Government Printer, Entebbe, Uganda. 1938.

Weaver, J. E. and Albertson, F. W. (1943).— "Resurvey of Grasses, Forbs and Underground Plant Parts at the End of the Great Drought." Ecological Monographs, January, 1943.

Weaver, J. E. and Albertson, F. W. (1944).— "Nature and Degree of Recovery of Grassland from the Great Drought of 1933 to 1940." Ecological Monographs, 1944.

Weaver, J. E. and Clements, F. E. (1929).— "Plant Ecology." McGraw-Hill Book Co. Inc. New York, 1929.

West, O. (1938).—"An Investigation of the Methods of Botanical Analysis of Pasture." S. Afr. Journ. Sci. Vol. XXXIII, 1938.

ACACIA BUSSEI HARMS. VERN. "GALOL"

HALEYA, 17TH DECEMBER 1945

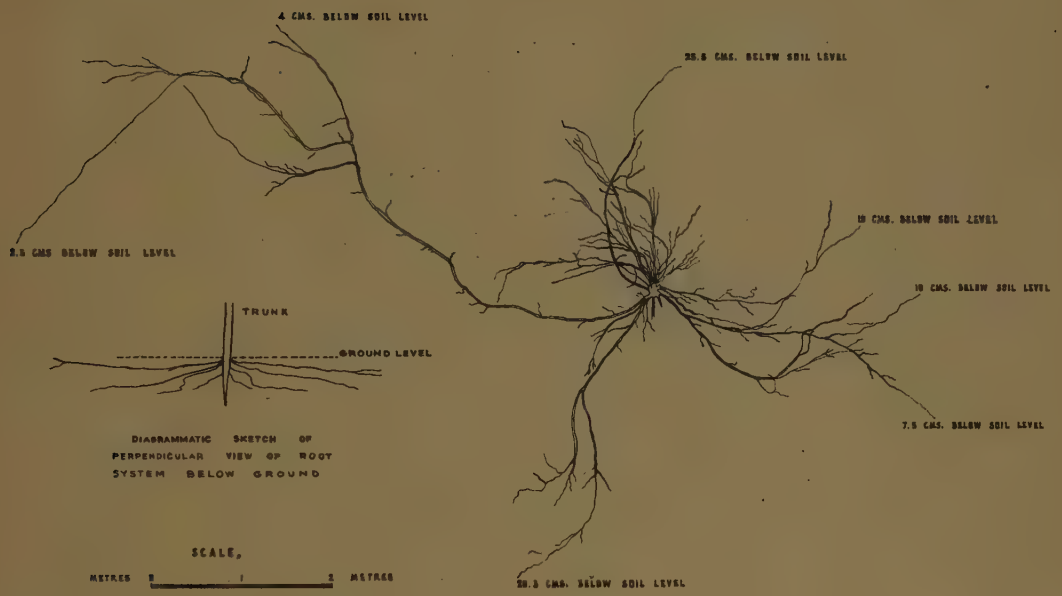


DIAGRAM TO SHOW CROWN-ROOT RELATIONSHIP

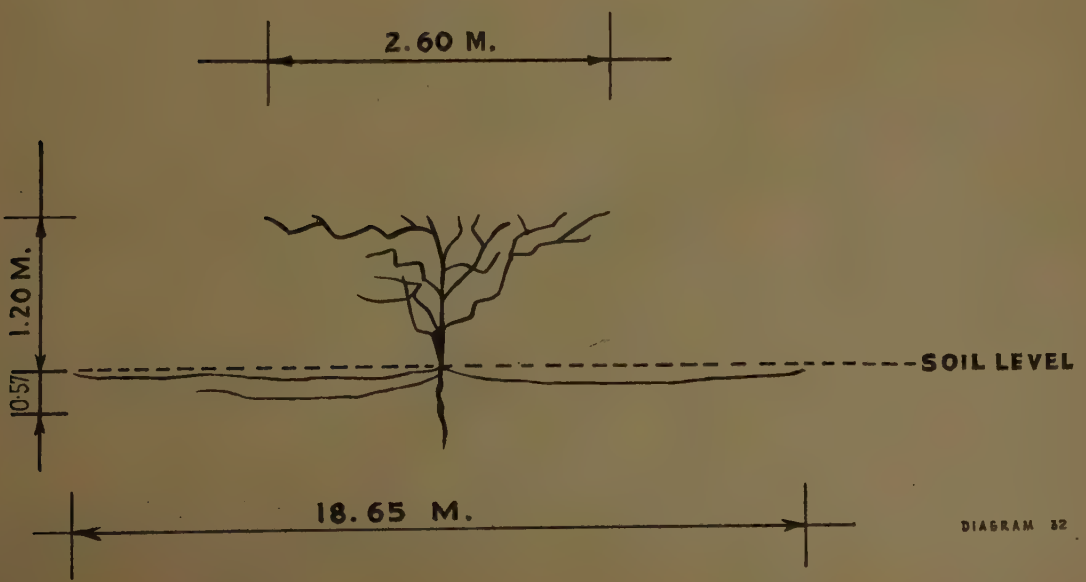


DIAGRAM 32

COMMIPHORA ANCISTROPHORA CHIOV. "DUNDAS"

4th OCTOBER 1945

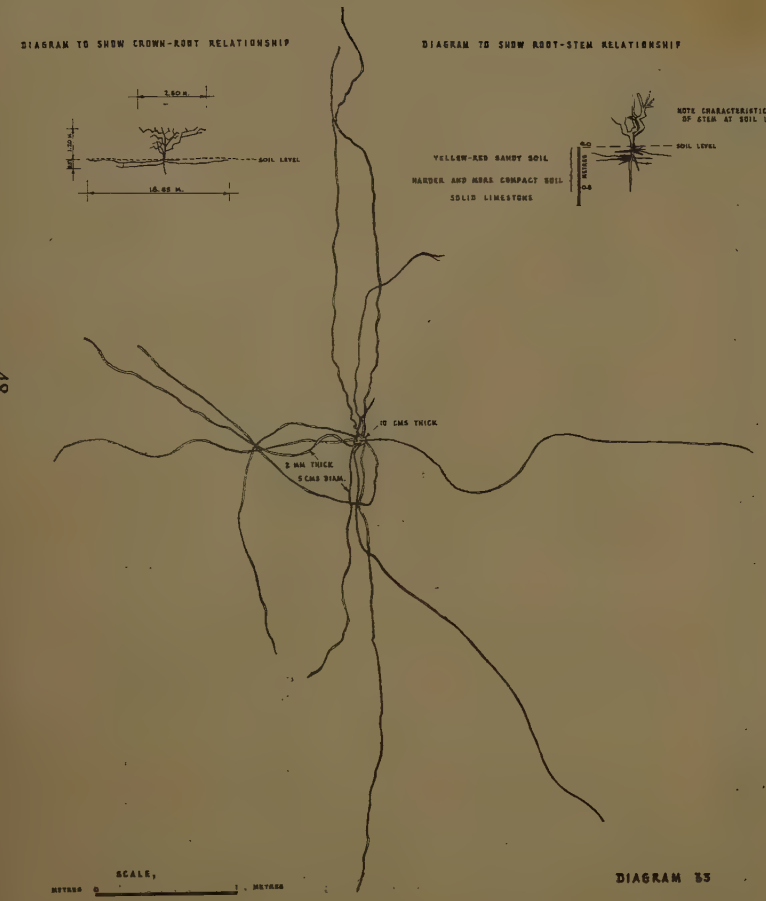


DIAGRAM 33

DIAGRAM 33

PLAN OF ROOT SYSTEM OF COMMIPHORA ERYTHRAEA ENGL. "HAGER AD"

ALABLAH BALLEH, WADERE DISTRICT OF THE HAUD - SOMALIA - 19th OCTOBER 1945

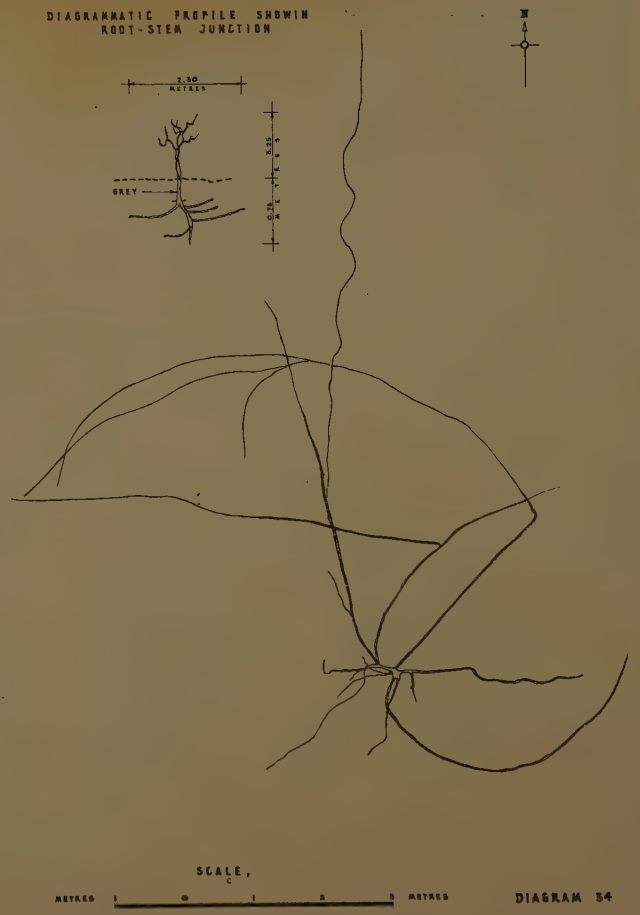


DIAGRAM 34

PLATYCELYPHIUM CYANANTHUM HARMS. VERN. "SABANSABADOH"

ALABLAH BALLEH, 29TH OCTOBER 1945

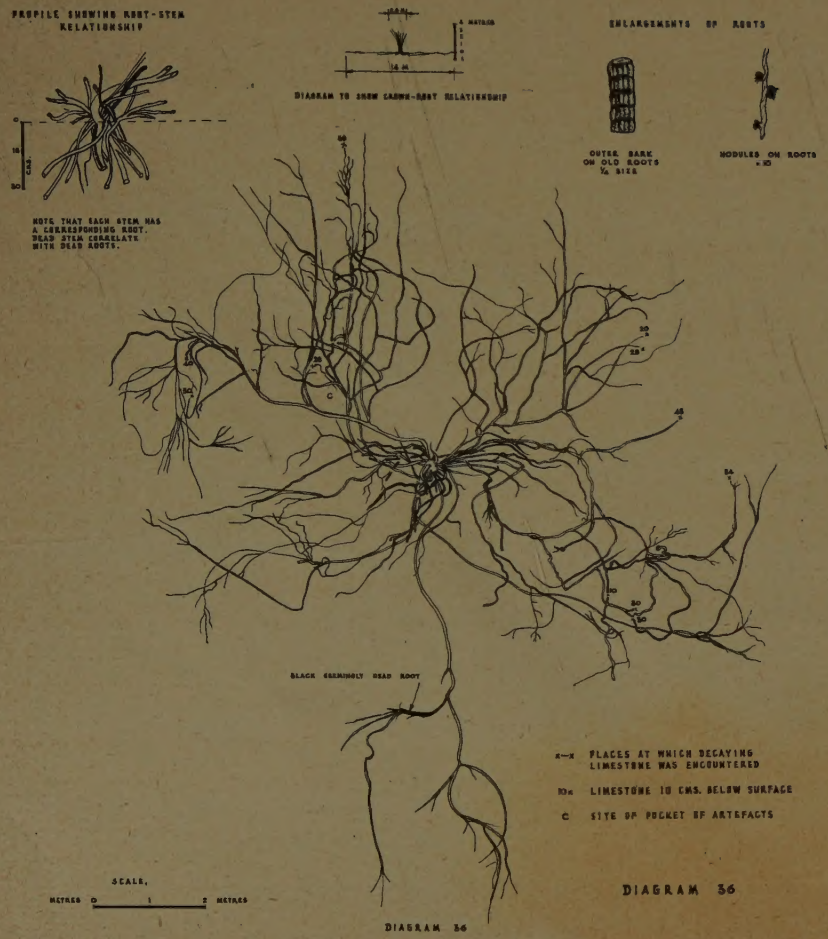


DIAGRAM 36

DIAGRAM 34

COMMIPHORA SP. VERN. "GARON MEDU"

ALABLAH, 4TH OCTOBER 1945

DIAGRAM 35

COMPOSITE ROOT BISECT SHOWING RELATIONSHIP OF ROOTS ALONG A FIFTEEN METRE TRENCH IN RED SANDY SOIL OF HAUD-TYPE OF COMMIPHORA-SCRUB AND GRASS VEGETATION

HRIA HEDE ON BOUNDARY CUT ROAD ON 24th NOVEMBER 1945

The bisect was 15 metres long when it was excised but before the work was begun but after the work had been completed it was found that it had increased to 17 metres. This was due to the fact that the roots of some of the plants extended beyond the original boundary.

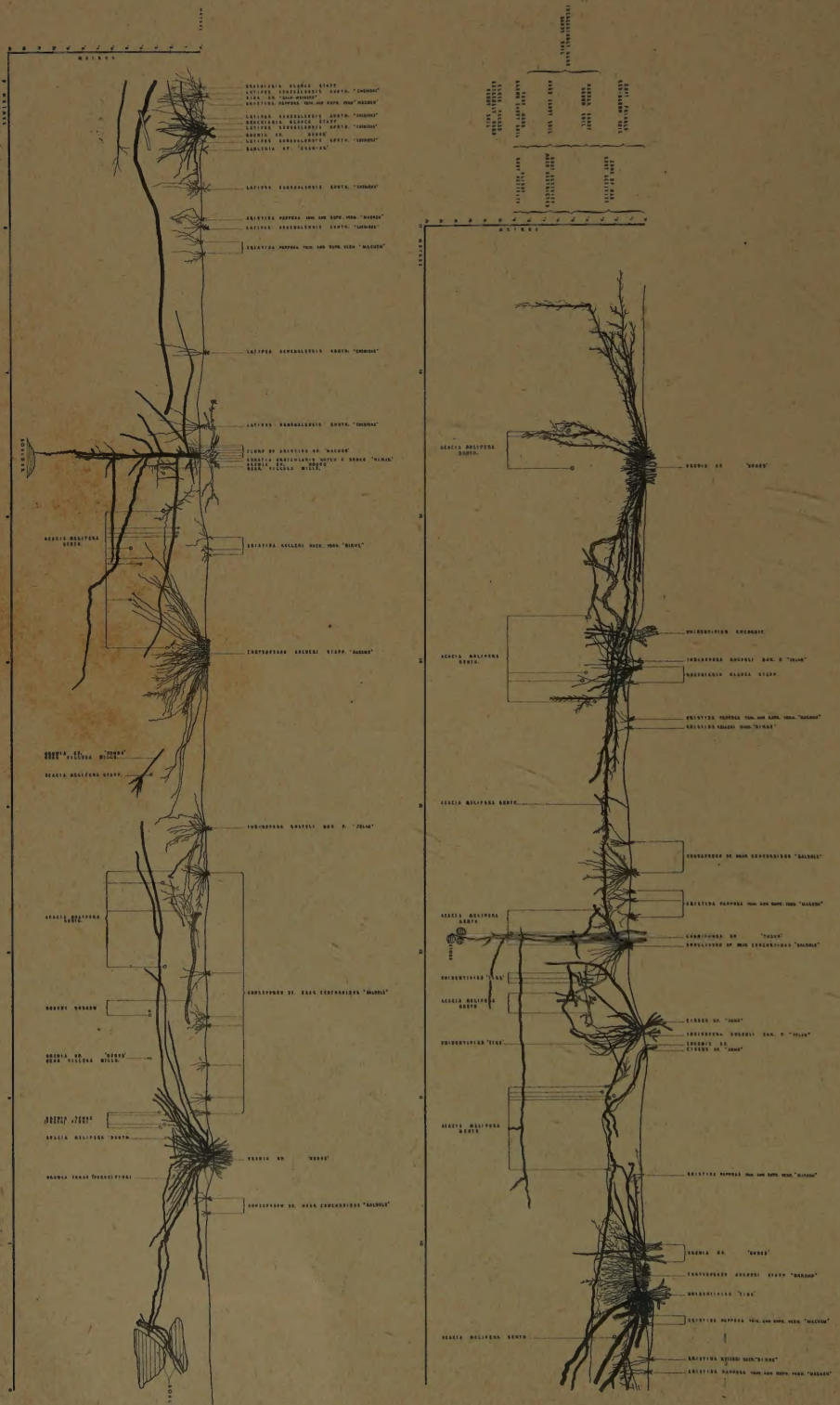
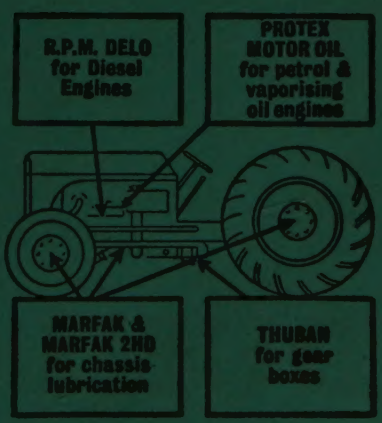


DIAGRAM 37

A TEAM TO TAKE THE LOAD OFF YOUR TRACTOR

Caltex technicians have developed a team of tough lubricants capable of standing up to the hardest tractor operation. Between them, these lubricants completely foil wear—saving money in two ways. In reduced maintenance costs—and by avoiding costly stoppages. To specify Caltex Tractor Lubricants is good business and good farming.



CALTEX

Tractor Lubricants

FILED IN STACKS